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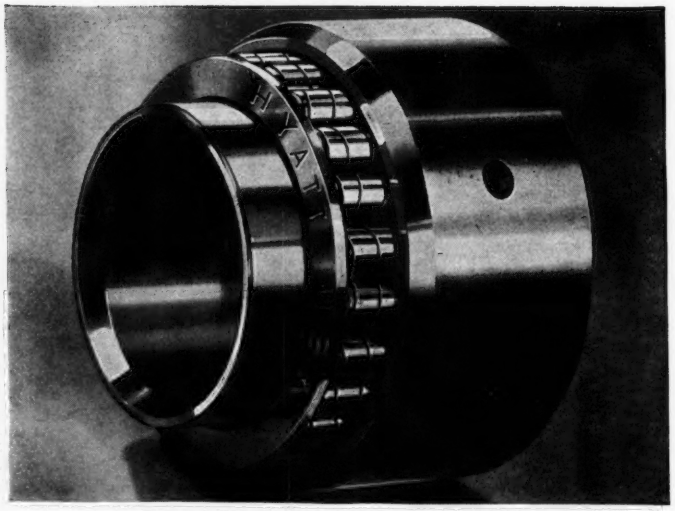

HYATT
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AGRICULTURAL ENGINEERING

Volume 13 MARCH, 1932 Number 3

Gear Loading Practice in Tractor Design[1]

By Louis Jacobi[2]

Mem. A.S.A.E.

GEARS as a means of transmitting power are very old. Much has been written and learned about this vital subject, but there is still room for improvement. The designing engineer, in laying out a transmission, a tractor transmission in particular, is at once confronted with a number of puzzling problems, especially if he is new in the field. Often an experienced man does not know which is the surest road to success coupled with economy for the product he is about to design. Granted that the involute tooth form is the accepted tooth shape, the designer finds the 14½-degree, 20-degree, 22½-degree, and other pressure angles coupled with standard tooth proportions, the stub tooth, the high and low addendum tooth and other tooth forms. Although these different modifications have their distinct places of application, there is a wide variation in consistency. When he comes to the selection of the material for gears, there are a great many steels from which to choose. The physical properties of the steel influence the design of the gear as to size to a certain degree. The chemical composition and method of making the steel govern the price of the material. Which is the best steel from the standpoint of satisfactory performance and low cost? Here again is wide diversity of opinion.

The steels most commonly used today for tractor gearing are the same as used for automotive gearing. Although their general properties are common knowledge, I believe it is not amiss to mention them briefly.

Steel No. SAE 2320 is a nickel carburizing steel with good casehardness, a strong core and a minimum amount of distortion. It is extensively used by a large number of gear manufacturers.

SAE 2512 is also a nickel carburizing steel of greatest core strength, and can be hardened at a low temperature with exceptional freedom from scaling and distortion.

SAE 3115 is a nickel-chromium carburizing steel which equals or outranks in use No. 2320. It takes a hard case and has a strong core, machines easily, and is considerably cheaper than 2320, but not as strong.

Good old SAE 1020 is still with us as a carburizing steel, also used for gears, and gives a good account of itself when the carbon content is controlled for uniform results. It may be single or double quenched to refine the core.

SAE No. 2350 is an oil-hardening steel of very great toughness, machines comparatively well, hardens to a great depth, and has good wear resistance. It is used mostly for oil-hardened transmission gears.

Since the alloying elements in nickel and chromium steels not only greatly influence the strength but also the price of the steel, these alloy steels should be used where their qualities can be taken advantage of to the fullest extent.

I have mentioned the properties of the various steels only in general, since it is not the purpose of this paper to delve into the realm of metallurgy. This is an immense subject in itself, and does not belong here. The designing engineer, however, must know enough of the complexities of the available steels to make the proper choice for the respective applications. He needs the cooperation of the metallurgical engineer extensively.

Good gear making starts out with the making of the steel. Controlled melting practice and correct rolling procedure play an important part. Rigid inspection of the raw material must be exercised; otherwise it may result in costly scrap of the finished or partly finished article. The same caution applies to the forging which, to begin with, must be properly designed. The finished forging must stay within its limits; the normalizing must be perfect; the gear must not stretch and strain every fiber to get out of bounds, due to incorrect grain flow or joining of sections of either too little or too much material accumulation.

Closest inspection must be extended to the finishing of the gear. Modern precision machines produce almost perfect gears, but frequent checking of equipment is necessary to insure true tooth spacing and a minimum of run out. It will not do to subject a precision-made gear to careless handling during the heattreating process. Distortion in carburizing and heattreating is the principal source of noisy gears and can be controlled to a minimum by careful handling in heattreating.

Whether to choose oil-hardened or carburized gears depends a good deal on the available equipment; both types have their advantages as well as

[1]A paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December 1931.

[2]Engineer, tractor engineering department, Allis-Chalmers Manufacturing Company.

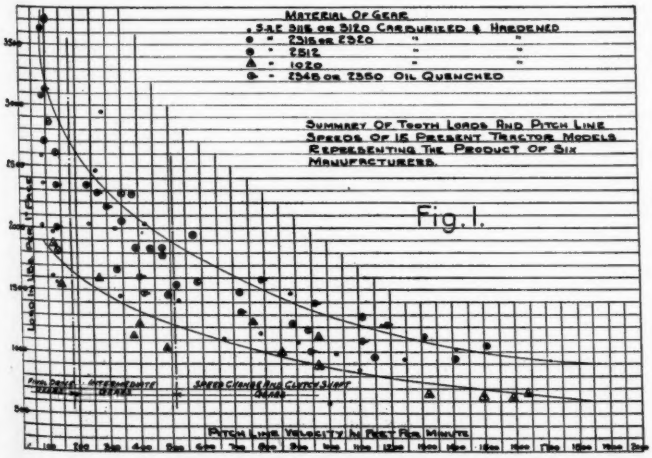

Material Of Gear
SAE 3115 or 3120 Carburized & Hardened
2315 or 2320
2512
1020
2345 or 2350 Oil Quenched
Summary Of Tooth Loads And Pitch Line Speeds Of 15 Present Tractor Models Representing The Product Of Six Manufacturers.
Pitch Line Velocity In Feet Per Minute

Fig. 1.

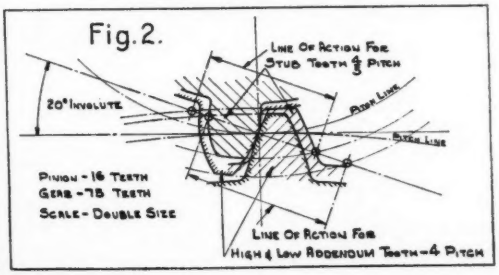

Line Of Action For Stub Tooth ¾ Pitch
20° Involute
Addendum Line
Pitch Line
Pinion - 16 Teeth
Gear - 75 Teeth
Scale - Double Size
Line Of Action For High & Low Addendum Tooth - 4 Pitch

Fig. 2.

their disadvantages. In general, oil hardened steel demands greater care in forging and annealing, and must be machined slowly. The quenching operation produces little warping, which means quiet running gears. The tooth is stronger than a carburized tooth, but is not as resistant to wear. The carburizing steel, on the other hand, forges and anneals with ease and can be machined with speed. As already mentioned, the carburizing operation must be done very carefully, and is expensive. The distortion is greater, but the gear has a long life, due to its hard face.

After we are assured of a good gear, it must be mounted properly to give a good account of itself. Here is where the designer comes in again for his share of responsibility. The bearings must be adequate and the shafts stiff enough to resist undue deflection. It is unfortunate that we cannot decrease deflection to a marked degree by selecting a higher grade material for the shaft, but the moduli of elasticity for the various steels are almost identical, in spite of the wide range of their other physical characteristics. We can reduce deflection, if not by a larger shaft, then probably by short bearing centers. The gear case must be designed so as not to deflect appreciably under the load. Short shafts and stiff gear cases with adequate bearings reduce deflection to effectless limits. A gear so mounted can be expected to carry a heavy load. All other factors being equal, it may be made narrower and in turn may mean a more compact crankcase.

Referring to Fig. 1, I wish to take this opportunity to thank the various members of this society who have supplied the author with the gear sizes and loads used in these tractors. This information was necessary to develop the data of this paper, since I wished to illustrate comparative figures, rather than give my personal opinion and observations.

We will compare the various tractor transmission gears for wear, as this is one of the most, if not the most, important consideration.

In making these comparisons, I have shown the load per inch of tooth face plotted against the pitch-line velocity. In designing transmissions for Allis-Chalmers tractors, a curve of this type is always made to serve as a guide in determining the sizes of the various gears.

On Fig. 1 we see the array of loads and velocities of all the gears. The horizontal lines give the velocities in feet per minute.

The loads have been calculated by using either the horsepower stated by the manufacturer or the Nebraska test loads which were brought up to 100 per cent at the clutch. Deductions for friction losses of 4 per cent of the load were made for each gear reduction. Whatever percentage is taken, the comparative relation will not be affected.

The gears naturally could be grouped into four divisions: Clutch-shaft gears, speed-change gears (of which only three speeds are tabulated), intermediate gears, and final-drive gears. The low and second speeds only are tabulated for the last two divisions. The mating gears, of course, do not appear, since the loads and speeds are identical.

Fig. 1 shows identification marks of the various gear materials, and two curves which, to a fair degree, represent the average loads and speeds found in tractor practice with various gear materials. Final drive gears are tabulated in the pitch line velocity range up to about 200 feet per minute. Intermediate gears occupy the range between 200 and 500 feet per minute. Above that range are the clutch-shaft and speed-change gears. The nickel steel gears indicated by circles occupy the upper range, and the SAE 1020 gears indicated by triangles, the lower one. One would expect the dot marks representing the chrome-nickel steel gears to occupy a center position between the upper and lower curves; that is, between the nickel steel and carbon steel gears; but some of these gears of SAE 3120 are on the upper curve in the range of the nickel steel gears.

If these chrome-nickel gears give a good account of themselves, it may indicate that the nickel steel gears could carry heavier loads than those tabulated. We deal here with the all-important wearing factor. It is a fact that the SAE 2320 and 2512 steel gears of our own product give excellent wear. It may well be possible to increase the loads per inch of face, since the backbone of the tooth —I mean the core strength—is present in those steels. The wearing qualities of the carburized gears in the different steels, I believe, do not differ to a very great extent. It is the strength of the core which finally determines whether or not we can make full use of the wearing quality. We cannot strengthen the core by selecting a heavier tooth. Although the tooth may be sufficiently strong to stand the shock tooth loads, the gear nevertheless may pit on the wearing face. The surface pressure is too great and breaks through the case, which it would not do if the case would rest on a sure foundation. As the house is not better than its foundation, so the carburized tooth is not better than its core.

The narrower the gear, the more evenly we should be able to distribute the load and correspondingly higher we could impose loads. It is the responsibility of the engineer to find the limit. Formulas will only serve as stepping stones. We must build on and look to experience as the best teacher. Take anti-friction bearings as an example. The allowable loads for bearings have been increased to an extent that would not have been possible ten or even five years ago. Better understanding of the underlying principles, better steel, and better manufacturing methods are responsible for the change. This also holds true with gears. Not to subject the material to the limit it will endure with safety is waste and is detrimental to sound economic conditions.

It is a practice to use stub-tooth gears on tractors almost exclusively. Allis-Chalmers has changed from stub-tooth to standard 20-degree teeth; and to long and short addendum teeth in such locations as the final-drive and intermediate gears, where the number of teeth in the pinion is small. In such cases the long and short addendum teeth have been modified as to pitch-line thickness of the tooth, to give about even strength for gear and pinion.

Fig. 2 shows the 4-pitch tooth of the final-drive pinion in double size. This pinion is charted on Fig. 1, topping the upper curve at the upper left-hand corner. I do not know of a single failure of this pinion made of SAE 2512 steel, or of the meshing gears of carburized 1020, due to worn out or broken teeth, a proof that this pinion is conservatively loaded.

In this sketch a standard 4/5-pitch stub tooth is shown within the long and short addendum tooth. It brings out the marked contrast between the two teeth. The pinion requires a somewhat larger outside diameter, but the gear outside diameter is even smaller than the stub-tooth gear diameter. One may argue the merits of long and short addendum gears. The fact remains, however, that in the above case the tooth is still about 30 per cent stronger in beam strength than the stub tooth in spite of the increased tooth height. The total tooth height is that of a normal 4-pitch tooth. The tooth contact is of somewhat longer duration than that of the stub tooth, which must result in lower contact pressures and a quieter running gear. There is more rubbing action as the tooth sweeps into contact, but the behavior of this pinion is excellent.

The engineer belongs to a conservative family of people, but is not slow in progress and is awake to the needs of the present and future. When we look back to the time when the tractor was in its infancy, when great monsters of iron and steel pulled the plows over the fields of the wheat-producing areas, and stop to compare the total gear weights with those of a modern tractor of equal horsepower, we find that their weight has been reduced by more than 80 per cent. Progress has been made.

In conclusion, allow me to express the wish that this paper may serve as a step towards developing a uniform gear loading practice in the tractor industry.

A Season's Test of a Hay Drier[1]

By Arthur W. Clyde[2]
Mem. A.S.A.E.

THE PENNSYLVANIA Agricultural Experiment Station, with several other stations and many progressive farmers, is interested in artificial means of drying hay. The livestock men think it has possibilities from the feeding standpoint, and the agronomist is concerned with putting his crops in usuable condition. The job of getting the drying done at a reasonable cost is mainly an engineering problem with several interesting angles.

In order to further the study of this subject, the Pennsylvania station this year secured a small commercial drier. Thus far we have put over 182 tons of green material through it and secured 64½ tons of dried product. The main crops used have been alfalfa, mixed clover and timothy, oats, barley, and silage corn. In addition, we did some work with high nicotine tobacco raised for insecticidal purposes, and also put 2300 pounds of combined wheat through the drier. Most of the forage crops will be tested for feeding value by the dairy department in comparison with naturally dried crops from the same fields.

It might be well to summarize the principal advantages hoped for from quick drying. The first one applies mainly to alfalfa. It is a useful forage crop but one which is hard to cure naturally in the humid sections. Probably much more would be grown to advantage in this section if it were not for the uncertainty and loss in curing. Artificial drying removes the weather hazard. Probably it also produces a higher protein feed, because practically all the leaves are saved.

The second advantage applies mainly to other hay crops, such as oats, barley, rye, etc. Some tests at least indicate that, if such crops are cut green and dried quickly, the protein content is higher than if cut when mature.

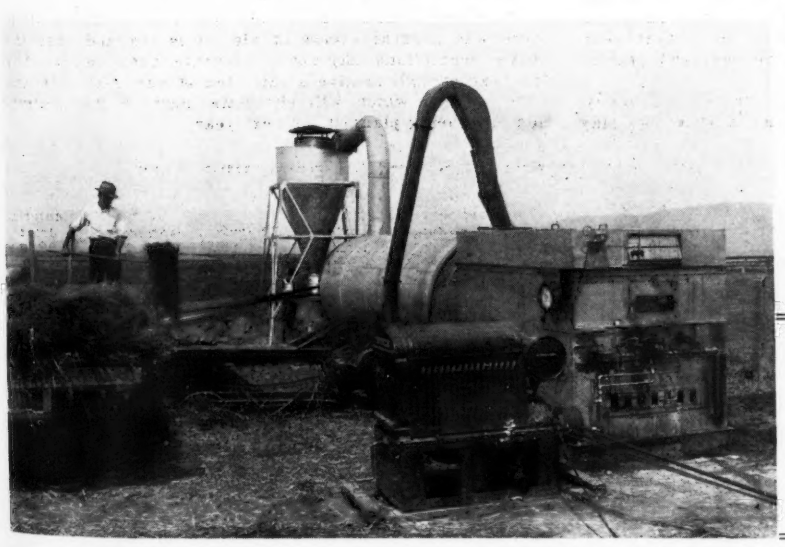
A third possible advantage applies to some special crops, as high nicotine tobacco. Quick drying saves a considerable expense for drying sheds. There also is indication that it will give a higher nicotine content by preventing most fermentation losses.

The drier we have is of the rotary, direct-drying type having a rated capacity of 1 ton of water evaporated per hour. By present standards it is a small machine. Green material is fed into the drying drum with all of the gases of combustion from the furnace. The outer drum is 6 by 16 feet in size. Inside of the main drum are two smaller concentric ones. The green material with the gases is drawn through by suction, first going through the smaller drum, then back through an intermediate space, and finally making a third trip next to the outer drum. After going through the fan it passes to a dust collector or cyclone separator and is bagged. Since the material is carried by an air stream, it is cut up before being fed into the drier. We used a silage cutter with forage feeder for that purpose. The length of cut was ¼ inch.

The drier has an oil-burning furnace. The control of heat is partially automatic. Two of the three burners are controlled by a thermostat at the outlet of the drying drum. If the gases leaving the drum are hotter than desired, the supply of fuel to the two burners is automatically reduced. Similarly, if the drum cools too much, the burners will be turned on to full capacity. There is no automatic protection, however, against overfeeding green material; if fed beyond the capacity of the furnace, the material will not be fully dried. To avoid this, we put a pressure gage showing fuel pressure on the two burners in plain sight of the feeder. The gage shows him how nearly to capacity the furnace is being worked and thus indicates whether he is feeding too fast or too slowly. One man new at the job said, "This is the first time I ever fed a silage cutter by a speedometer."

As we are set up, two power units are required. About 7½ horsepower is needed by the cutter and about 15 horsepower by the fan, drum, fuel oil, pump, and air pump. We used tractors, a stationary engine and a 7½-horsepower electric motor, according to what was available at any particular time.

In general, the results have been quite encouraging from the standpoint of the engineer. We have been able to turn out what appeared to be a splendid quality of alfalfa in rainy spells when natural drying failed almost completely. As will be pointed out later, drying under such conditions is more expensive than in normal weather. We have not been able at any time to dry as cheaply as some of the larger installations. That probably is due to the fact that with our small machine the labor costs per ton are higher, and to the fact that we paid more for fuel than would always be necessary. In learning how to operate the machine, we have turned out a little material which was not dry enough to keep. We have had a few sacks catch fire and have learned thereby that direct-heat driers using temperatures up to 1000 or 1100 degrees are not foolproof. Our experience has shown that the two main fire



This shows the Arnold forage crop drier (Ardrier) owned by the Pennsylvania Agricultural Experiment Station, on which the tests reported in Mr. Clyde's paper were conducted

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December 1931. Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 544.

[2]Research agricultural engineer, Pennsylvania State College.

risks are in allowing the cyclone to clog, thus causing some dried hay to be overheated, and in feeding a partly dried hay back into the machine when some of it is already dry.

Mechanical troubles have not been serious. The one which caused most delay was the loss of prime of the fuel oil pump. This was partly a fault of installation, and I think will give no more trouble now that we have the suction line fixed so that all air can be easily removed from it. When handling very wet alfalfa we also had some trouble with the feeder on the drier and with wrapping in the hay cutter.

For all material except wheat the average fuel oil consumption has been 31.1 gallons per ton of water evaporated. This varied from 26.3 gallons with one lot of oats to 43.7 gallons with one lot of alfalfa. Fuel consumption per ton of dried hay naturally varies widely with materials of different wetness. For example, two different lots of alfalfa required 43.8 and 98.6 gallons per ton of dried hay.

Out of the many interesting phases of this subject there are two questions which seem most important if the cost of drying is to be kept low:

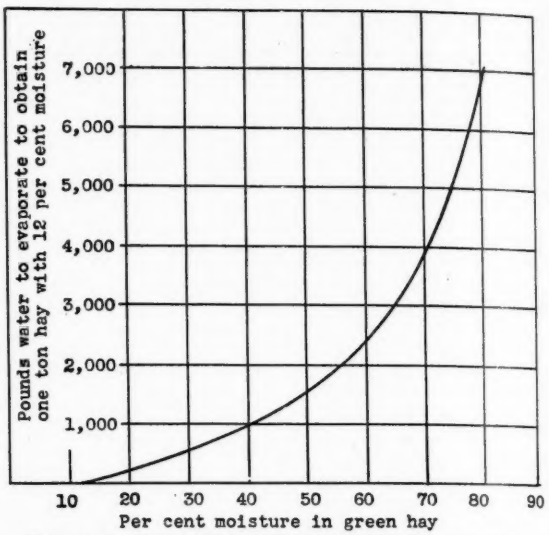
1. How far can natural drying be used to assist artificial drying?

2. How can the thermal efficiency of driers be improved?

In considering the first question, it will be appreciated that the amount of fuel per ton of dried hay, the time. and the cost depend largely on the amount of water to be evaporated. It may on occasion be desirable to handle a very green crop in the rain, but I doubt whether it will always be economical to do so. Two examples will show the great difference which partial natural drying will make in regard to the amount of water to be evaporated in the drier. Suppose a lot of hay, having 75 per cent moisture, is to be dried until the moisture content is 12 per cent A ton of hay with 12 per cent moisture contains 1760 pounds of dry matter and requires 1760 ÷ (1 — 0.75) or 7040 pounds of green hay. It is, therefore, necessary to remove 7040—2000, or 5040 pounds of water. If, however, the hay can be allowed to dry in the field until it contains 60 per cent moisture, it is then necessary to remove only 2400 pounds of water, or less than half that in the 75 per cent hay. The accompanying graph shows this relationship. It differs somewhat from similar curves already published.

From the examples cited and the curve in the graph, it is evident that a substantial saving in drying costs can be made if nature helps with some field curing. I do not mean that every crop can be allowed to dry to 60 per cent moisture, but merely use that as an example. As far as I know, it has not yet been determined how far natural drying can be allowed to go before the feeding value may be impaired, leaves lost, etc. If such information is not available, I hope we can do something on it next year, as it has an important bearing on the cost and practicability of artificial drying.

The second question, that relating to thermal efficiency, is a most interesting one. It is also one in which we may



This graph shows the relationship between the percentage of moisture in green hay and the amount of water to be evaporated to obtain hay with 12 per cent moisture

get considerable help from mechanical and ceramic engineers who have similar heating and drying problems. A given fuel can produce a certain amount of heat. The problem is to reduce the heat loss so that as much heat as possible may be used for drying.

The first logical step seems to be to find out where the heat from the fuel goes. With the help of Professor J. B. Shaw of the ceramics department at Pennsylvania State College, we put in a pyrometer to get the temperature of gases as they passed from the furnace to the drier. Thermometers were used at the point where the gases were discharged into air and at an intermediate point near the fan. After some preliminary observations a test of 1 hour and 45 minutes was made in which fuel was weighed and temperatures taken every 5 minutes. Time did not permit setting up apparatus to measure the flow of gases through the drier. This was calculated by figuring the amount of air which could be heated to the observed temperature after making the following assumptions:

Heat value of fuel oil (higher), 20,000 Btu per pound
Hydrogen in fuel oil, 13 per cent
Water in fuel oil, 1 per cent
Radiation loss from furnace, 3 per cent.

Complete combustion of fuel was also assumed since there was a great excess of air. It is realized that the above assumptions may not be accurate, but I believe they are near enough to give a fair idea of our heat uses and losses. Tests which will eliminate most of the assumptions are being planned for next year.

Results of Forage Crop Drying Tests at the Pennsylvania Agricultural Experiment Station in 1931

Material dried	Weight wet, tons	Weight dried, tons	Weight lost, per cent	Fuel per ton of water evaporated, gallons	Fuel per ton of dried materials, gallons	Thermal efficiency, per cent (a)	Water evaporated per hour, tons (b)	Material dried per hour, tons (b)
Alfalfa, 1st cutting	37.47	14.58	61.1	27.9	43.8	57.6	0.89	0.57
Alfalfa, 2nd cutting	21.48	6.96	67.5	33.4	69.7	48.1	0.68	0.33
Alfalfa, 3rd cutting (c)	15.38	4.72	69.4	43.7	98.6	36.8	0.50	0.22
Clover and timothy	20.19	7.69	61.8	27.6	44.9	58.1	0.92	0.57
Oats	55.93	18.36	67.2	28.8	58.9	55.8	0.90	0.44
Barley	9.59	4.06	57.6	33.6	45.8	47.7	0.91	0.66
Corn, late silage stage	14.93	6.62	55.6	33.1	41.5	48.6	0.77	0.61
Tobacco	5.56	1.11	80.1	34.2	136.9	47.0	0.67	0.17

(a) On the basis of 1100 Btu per pound of water evaporated, fuel oil 6.84 pounds per gallon and 20,000 Btu per pound.

(b) For net feeding time not including delays, starting and stopping.

(c) Poor results on this run were partly due to delays caused by wet alfalfa wrapping in the cutter and by some belt trouble. These hardly seem enough explanation for the results, however.

TEST DATA

Material dried, alfalfa (second cutting)
Weight green, 3,300 pounds; weight dried, 883 pounds
Difference (considered as water evaporated), 2,417 pounds
Rate of evaporation, 0.69 tons per hour, or 23 pounds per minute
Fuel consumption, 2.27 pounds per minute. (Fuel was 39½ degrees Baume at 60 degrees temperature. At 80 degrees it was 41 degrees Baume, or 6.84 pounds per gallon)
Average rise in temperature of gases leaving furnace, 932 degrees (Fahrenheit)
Average temperature of exhaust gases, 292.6 degrees
Average air temperature, 80¾ degrees dry; 68¼ degrees wet bulb
Average air humidity, 53 per cent relative, or 0.012 pound of moisture per pound of dry air
Temperature of dried hay, 180 degrees (approximate)

Calculations for Gases Leaving Furnace per Minute

1. Water produced by burning H in fuel,
   2.27 x 0.13 x 9 = 2.656 pounds
2. Total water from fuel,
   2.656 + (1 per cent of 2.27) = 2.679 pounds
3. Heat taken by water from fuel,
   2.679 [(212 — 81) + 970 + 0.48 (1013 — 212)] = 3,980 Btu
4. Higher heat from fuel,
   2.27 x 20,000 = 45,400 Btu
5. Estimated radiation loss from furnace,
   3 per cent of 45,400 = 1,360 Btu
6. Heat available for warming air plus its water vapor,
   45,400 — (3,980 + 1,360) = 40,060 Btu
7. Heat needed to raise 1 pound of air plus its water vapor, 932 degrees, 932 [0.24 + (0.48 x 0.012)] = 229 Btu
8. Amount of air plus its vapor which can be heated to 932 degrees, 40,060 ÷ 229 = 175 pounds

The foregoing method assumes that the weight of gases leaving the furnace is the same as that of the entering air. Actually in burning 2.27 pounds of fuel oil there is a loss of dry gas weight of about 0.4 pound because more oxygen from the air is used to form water vapor than is added to the gases by carbon from the fuel. This item is disregarded because the accuracy of the test hardly warrants its inclusion and because the error in the heat balance caused by it is very slight.

In practice, additional air enters the drier with the green hay. Estimating it at 5 per cent gives 175 x 1.05, or 183.7 pounds gases and their water vapor passing into the drier per minute (about 2,590 cubic feet, at 14.09 cubic feet per pound at 81 degrees).

The heat balance may now be computed; the figure of 0.42 for specific heat of hay is from the U. S. Department of Agriculture.

Heat Balance

	Btu per minute	Per cent of heat of fuel
Dry exhaust gases, 183.7 x (292.6 — 81) x 0.24	9,320	20.5
Water vapor in air, 183.7 x 0.012 x (292.6 — 81) x 0.48	230	0.5
Water from fuel, 2.679 x (131 + 970 + 80.6 x 0.48)	3,050	6.7
8.41 pounds hay heated to 100 degrees, 8.41 x 100 x 0.42	350	0.8
Radiation from furnace (estimated)	1,360	3.0
Radiation from dryer and unaccounted for (by difference)	4,900	10.8
Superheating water vapor from hay, 23 x (292.6 — 212) x 0.48	890	2.0
Evaporating moisture from hay at 212 degrees, 23 x [(212 — 81) + 970]	25,300	55.7
Totals	45,400	100.0

The last item is usually considered useful work, giving a thermal efficiency of 55.7 per cent. Longer tests went as high as 61 per cent, but the average for the season was 52 per cent on the basis of 1100 Btu required to evaporate one pound of water. Probably a higher efficiency might have been obtained in this test, if the burners had been adjusted to burn fuel faster with a resulting higher capacity for the drier. No means had been provided whereby the operator could be sure of getting any certain burner adjustment, therefore, his judgment was a large factor as to the rate of burning fuel.

In examining the losses the size of the first item attracts attention. The 183.7 pounds of dry gases carry nearly 28 pounds of water vapor, or about 1060 Troy grains per pound of gas. The chart on page 197 of "Drying and Processing of Materials," by the Carrier Engineering Corporation, shows that the dew point of these gases is 138 degrees. To reach 30 per cent humidity they would have to be cooled to about 188 degrees, or at least 100 degrees cooler than discharged during the test. This suggests two possibilities

1. Reducing the temperature of the exhaust gases
2. Reducing the flow of gas through the drier.

The first method would reduce the heat carried away by all water vapors as well as that carried by the dry gases. The second method would reduce the gas losses, and would, at the same time, reduce both the gas velocity and the speed of the hay going through the drier. It seems likely that, if the hay is kept in the drier for a longer time, it might be dried by less gas discharged at a lower temperature and higher humidity without reducing the drier's capacity.

A third possibility might be to recirculate some of the gases. The chances for saving by that method, however, are probably limited because the moisture carried by the gases would go back into the drier.

A fourth possibility for saving is to better insulate the drier. At present there is about ½ inch of insulation on the shell of the drier drum, but none on the ends and none on the fan and pipe going to the cyclone separator. In operation the losses from the drier drum are greater than from the furnace because the outer surface is hotter and because there is considerably more surface exposed.

A fifth possibility which appears to be promising is to regain some of the heat in the discharge gases and vapor by using them to preheat the green hay or entering air, yet not recirculating the vapor. A simple form of preheater might be a pipe carrying the green hay or the entering air, the pipe being surrounded by exhaust gases. If it should be possible to cool the gases below their dew point, then latent heat would be regained as well as sensible heat. We have not yet attempted to design a preheater nor figure whether its saving would justify its cost. There is no question, however, but that considerable heat is being wasted in the exhaust gases and vapors. All that is needed to save some of this waste is a practical preheater for applying some of the heat to the green hay and the entering air.

Profitable Rural Distribution[1]

IN THE SERVICE of rural territory the distinctive problem is one of high expenditures, extremely high operating costs and low returns.

Of the companies at present engaged in rural service very few claim to be making a profit, some are just breaking even, others are suffering a loss.

. . . . . .

The first essential for successful rural distribution is that it be built to a preconceived and definite plan. To attempt to build a profitable rural distribution without a systematic plan is from the outset a hopeless proposition. The initial revenue from a rural distribution system is poor—very poor.

To build a system with sufficiently low operation costs and sufficiently low capital expenditure to permit of an initial rate which is sufficiently low to permit of growth of business, is a difficult problem even with the most careful planning and most rigid economy.

To add to this the cost of expensive replacements and changes of voltage before the system is half depreciated, due to building without plan or thought of the future is to put one's self in the position of a swimmer struggling upstream against the current with a millstone round the neck.

Ideally, before starting out on a rural distribution system program, the whole system as it is expected to be when fully developed in the future should be laid out, and each annual program of extensions should be a definite part of the final plan.

We know that in practice it is not always possible to see sufficiently ahead to attain this ideal; conditions and emergencies will crop up which cannot be foreseen; but the nearer this ideal can be attained the more prospects are there of a successful result.

[1]From a paper on this subject by Maurice J. Kelley, in the February 1932 issue of N.E.L.A. Bulletin.

Underdrainage As Protection of Crops Against Drought Damage[1]

By Jesse H. Neal[2]
Assoc. A.S.A.E.

THE FINE-TEXTURED SOILS make up about 25 per cent of the agricultural land in the north central states, 5 to 10 per cent being strictly clay soils while the remainder is classed as clay loam or silty clay loam. Much of this cannot be cultivated to the best advantage without some artificial drainage. The extent of this drainage must be governed very largely by the productive value of the land when drained. The more intensive the cultivation the more complete the drainage should be.

The primary purpose of drainage is to remove the excess or injurious water, but the ultimate and more far-reaching purpose is insurance against subsequent drought. Since many clay soils do not seem to the casual observer to need artificial drainage, except during the early part of the growing season, many farmers do not realize the importance of drainage in dealing with such soils. When the water table is high during the early growing season, the root penetration will be very shallow. Later in the season when the water table is dropping rapidly, the roots, by that time more or less stunted, cannot keep up with the lowering water table and the plant soon suffers, or dies for lack of moisture. If the water table could have been held lower when the roots were making their greatest growth, their penetration would have been greater and the subsequent damage by drought greatly reduced.

This paper will deal with those soils having a moisture equivalent of 25 or above. Although those soils within the lower limits are not strictly clay soils, they are considered as such by the layman.

Soil Characteristics. In a cubic foot of clay the soil particles occupy from 40 to 55 per cent of the total volume. The remainder is pore space filled with water or air or both. The finer the soil particles, the smaller the openings between them. In the case of the clay soils most of the pores are of capillary size. (See Fig. 1.)

The usual terms of "light" and "heavy" soil refer, not to the weight but to the ease or difficulty of working the soil, the clay soils being referred to as "heavy soils." The more clay a soil contains the less its apparent specific gravity and the greater the amount of pore space, the weight and pore space being inversely proportional. The author has found that there is a fairly uniform direct proportion between the amount of pore space and the moisture equivalent of the soil. (See Fig. 1.)

Water Capacities and Relation to Drainage. The maximum amount of water a saturated soil will hold is equal to its pore space. For clay soils this amounts to from 5 to 7 inches of water per foot depth of soil. Israelsen (7)[3] and Davis and Adams (5) have concluded that, in most cases, the laboratory methods used to determine the maximum water capacity give results which are far in excess of the retentive power of the same soils under field conditions. The laboratory-treated soils permit a large amount of swelling, while under field conditions little if any swelling takes place.

According to Kopecky (8) the volume of capillary pore space is equal to the absolute water-holding capacity expressed on a volume basis, the absolute water-holding capacity being the amount of water the soil will hold against gravity, that is, the capillary water.

The maximum capillary capacity of clay soils as determined by several investigators, including Alway, Israelsen, Harding, Shaw, and others, is approximately equal to the moisture equivalent. From 3.5 to 6.5 inches of capillary water can be held in each foot of soil. This water cannot be removed by drainage and about two-thirds of it is available to plants. The difference between the saturated capacity and the capillary capacity is the amount removed by deep seepage or by tile drains. The nearer the capillary capacity approaches the saturated capacity, the slower the rate of movement of the gravity water through the soil. In fact this movement becomes almost a capillary movement for the extremely fine clays.

Robey (10) cites a case in the clay soils of the upper peninsula of Michigan in which the ground water table was not lowered at all beyond a point only six feet distant from a tile line. A similar condition was observed in the tight red clay of northeastern Minnesota at the North East Experimental Farm in 1922. Even under the most intensive cultivation returns would not warrant placing tile lines only 12 feet apart. Unless some artificial method is used to open up such soils to a considerable depth, extensive tile drainage is of little use in them.

Kopecky (8) states that, for optimum conditions for the root growth of grain crops, 20 to 30 per cent of the total pore space should be filled with air and the remainder with water. When the noncapillary pore space is less than 20 per cent of the total pore space, optimum conditions cannot be attained. Only plants which tolerate a high moisture content can be grown unless the soil is given special treatment to cause floculation for the purpose of increasing the noncapillary pore space.

Root Penetration. Most of the studies thus far made of root penetration have been done on the fine sandy loams as it is much easier to wash the soil away from the roots. The work done by Stewart (11) and Weaver (12) shows definitely that the roots of the usual cultivated crops will not penetrate a saturated soil, especially if there is no movement of the water.

Alexander (1) gives the results of sugar cane root penetration on drained and undrained clay soil in Hawaii. The first 8 inches of soil contained 97 per cent of the roots in the undrained area and only 75 per cent of the roots where tile drains were effective. The second 8 inches contained 3 per cent of roots in the undrained and 18 per

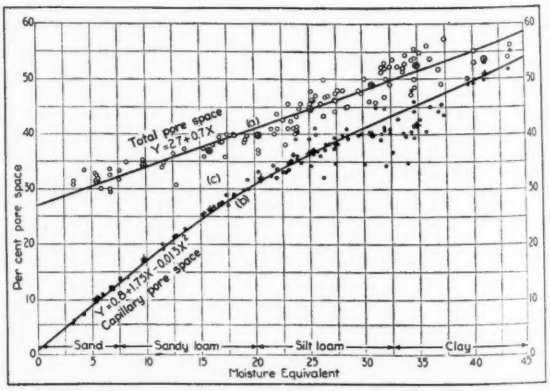


Fig. 1. Pore space of soils. (a) Total pore space—per cent by volume. (b) The pore space occupied when the moisture content equals the moisture equivalent

[1]Paper presented at a meeting of the Land Reclamation Division of the American Society of Agricultural Engineers at Chicago, December 1931. Approved as Miscellaneous Journal Series Paper No. 251 of the Minnesota Agricultural Experiment Station.

[2]Assistant professor of agricultural engineering (reclamation), University of Minnesota.

[3]Figures in parenthesis refer to the references under the heading "Bibliography" following this paper.

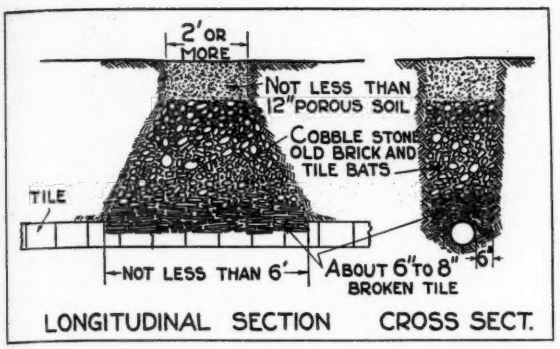


Fig. 2. Section views of a surface inlet to a tile drain designed to carry flood water in cultivated fields

cent in the drained area. Roots were found at a depth of 40 inches in the drained area, 7 per cent being more than 16 inches below the surface. The cane growing on the drained area had 60 per cent more roots than that on the undrained area. Plants on the drained areas were able to withstand a prolonged drought while those on the undrained area were unable to withstand any dry weather.

Wood (14) says that "on river bottoms and other low lands the water table is often too high in the spring of the year to permit the proper growth of plant roots. Under such conditions crops may suffer worse during the dry months. . . . . , than those on the hilly ground. The solution here is complete drainage; . . . . . laterals laid at intervals of from 40 to 100 feet apart."

Since many of the extremely fine-textured soils have a capillary water capacity very nearly equal to the saturated capacity, the plant roots will mature early very near the surface of the soil. In case of a dry spell later in the season, the moisture is soon exhausted by transpiration from the surface root zone and even though there is sufficient moisture 3 to 4 feet below the surface, the plants suffer or may even die for lack of water because capillarity is too slow to raise enough water to supply the roots, and the root system will grow no more having already reached maturity. The root penetration can be increased in these soils by mole drainage, by deep cultivation, and by the addition of lime and organic matter which tends to floculate the soil and to produce larger pore spaces. Where and when it is possible to grow them, deep-rooted plants as sweet clover and alfalfa help to open up tight subsoils, but these plants are hard to start in a wet soil.

Design of Drainage Systems in Clay Soils. Very little definite information is available as to the influence of tile drains upon the movement of water in clay soils, but it is generally agreed that the movement is very slow and that tile lines must be laid shallow, 30 to 36 inches, and spaced very close, 60 feet or less, to be effective. When there are depressions or pockets, such as are often found in the glaciated regions, the water will collect in them and stand for hours or even days although there is a tile line under the pocket.

To avoid flooding, two things were done at the North East Experimental Farm at Duluth, Minnesota, where only a skeleton tile system was installed, tapping all pockets and seepage spots. First, shallow V-shaped ditches, 1 to 2 feet deep and 10 to 20 feet wide on top, were constructed to carry the flood water, permitting the use of a much smaller main tile. Second, in all the pockets, surface inlets were constructed by widening the trench above the tile and refilling with tile bats and cobblestones up to a foot from the surface, then covering with a very pervious soil. (See Fig. 2.) A good inlet will take the water as fast as the tile can carry it away, never permitting the water to stand over the tile and puddle the soil. Although the tile lines were not spaced close enough to lower the ground water quickly following a rain, little trouble was encountered during the growing season. Since neither the shallow ditches nor the surface inlets to tile interfere with farm operations, a very effective drainage system can be installed at a relatively low cost on gently rolling land.

On flat lands ridging has been found to be very effective. A good example of this is the "semi-grand bank system of surface drainage" on the impervious clay soils on the sugar cane plantations of eastern Cuba, described by Ramos (9). In this case V-shaped ditches 15 inches deep and 24 feet apart were constructed with a Martin ditcher. The dirt from the ditches was spread out forming a ridge or bank between them. These soils were too impervious to secure any results with tile drains.

A similar case of ridging was employed on the flat truck farms at Meadowlands, Minnesota. The ditches on these farms were 12 to 18 inches deep, 100 feet apart, and one-fourth to one-half mile long, finally discharging into dredged ditches. The fields were plowed in permanent lands and the deadfurrows between these lands were cleaned out with a road grader, the dirt being shifted toward the center of the land with a heavy drag or leveler. This soil, being a sandy clay to clay, is not particularly impervious, but owing to the nature of the crop, it was absolutely necessary to prevent flooding, and tile drains alone, besides being relatively high in cost, would not respond quickly enough.

In many sticky soils it may be feasible to employ ridging as a supplement to tile drains thus permitting a wider spacing of these drains. In this way ridging has been found to be very effective in Holland. It is advisable to have surface inlets where the ditches cross the tile lines.

Although mole drainage has not been employed to any extent in this country, the author is convinced there is a place for it in supplementing tile drains in the sticky soils, especially in relatively flat areas, such as the Red River Valley of the North. Mole drains have been employed in Europe for over 100 years, and have proven very satisfactory, usually lasting from 5 to 10 years, and, under the most favorable conditions, even twice as long (2). Whallon (13) states that although some mole drains have lasted 20 years, the usual life is 3 to 4 years. Even for this short life mole drainage is justified as the cost is low and the soil is opened up aerating it and making it more receptive of water, the excess passing off through the mole drains. Root penetration and the ability to withstand subsequent drought will also thereby be increased.

The mole drains should be placed 1 to 2 feet deep and 1 to 2 rods apart running at right angles to the tile lines. Some of the European writers (2,3,6) recommend even closer spacings (4 to 15 feet), but American writers (10,13) suggest spacings of 1 to 2 rods, making new intermediate drains every 2 to 5 years.

The spacing of tile lines will depend mostly upon relative locations and frequency of the wet pockets and natural surface water courses. To get the best results the tile trenches should be refilled with a pervious soil, but this is not always possible. Covering the tile to a considerable depth with coarse hay will help. This is done very extensively in Europe and has been used effectively in northern Minnesota of late years.

Extent to Which Drainage Is Justified. Since the clay soils are difficult to drain and not all forms of drainage prove effective, it is unwise to launch immediately into an extensive and costly system of drainage. Drainage must be looked upon as an investment and the extent of this investment should be determined by the returns, not for 1 or 2 years, but over a 20 to 40-year period. In bringing wet clay lands under cultivation, the first step is to provide for the removal of the surface and flood waters by connecting the pockets with shallow V-shaped ditches or by ridging. Then the soil can be improved enough to grow some kinds of crops tolerant of wet conditions. The shallow ditches can be put in very cheaply with a road grader or Martin ditcher, using either horse or tractor power. They cost about $30 to $50 per mile. After the land has been cropped for a few years, more intensive drainage may more readily be installed, usually with profit, depending

upon the type of crops that it is planned to raise, and on the known return from the land.

Robey (10) suggests spacing tile lines 8 to 20 rods apart and cross hatching the area with mole lines. The mole drains cost about $2.00 per acre when spaced 2 rods apart. By supplementing tile with this and other forms of drainage, the cost will be much reduced while the effectiveness will be greatly increased.

SUMMARY

The volume of capillary pore space in clay soils is large —35 to 55 per cent of the total volume. That of the noncapillary pore space is very small—not over 5 to 10 per cent of the total volume. Both are very finely divided; hence, the rate of movement of excess water through clay soils is very slow, approaching that of capillary movement. The saturated capacity of clay soils ranges from 5 to 7 inches per foot of depth of soil, while the capillary capacity ranges from 3½ to 6½ inches, the difference being the amount of water free to drain away.

If the surface flood water can be removed quickly, and if the excess moisture in the top 2 or 3 feet of soil can be removed early enough in the growing season to permit deep root penetration, the practical bearing of the foregoing facts, relative to pore space and soil water movement, on crop growth is twofold:

1. Waterlogging and consequent drowning out and winter-killing are largely checked if not entirely prevented
2. Such soils hold sufficient capillary water to carry plants over a dry spell of considerable duration.

As many clay soils are too impervious to permit percolation of water to underdrains fast enough to prevent waterlogging, provision should be made early for the quick removal of most of the excess water by the use of surface drains and surface inlets into tile drains, and even of mole drains. After the excess water has been thus removed clay soils can be made more pervious by the addition of lime and organic matter and by deep cultivation. Then tile drains will aid greatly in keeping the soil in optimum condition for plant growth.

The ultimate purpose of farm drainage is to induce deep rooting as insurance against drought. For the same reason that they do not respond quickly to tile drainage, clay soils are not as quickly affected by drought as are soils of coarser texture. Hence plants grown in clay soils not too wet for adequate root penetration will be less quickly injured by drought than will those grown on coarser soils because clay soils seldom get entirely dry within the lower root zone except in periods of prolonged drought.

Owing to the fact that clay soils do not naturally furnish a quickly available reservoir for the storage of moisture to be drawn upon during periods of curtailed rainfall, much of the precipitation is apt to be lost as run-off unless artificial methods are used to open up these soils and make them more receptive of moisture. Any attempt, therefore, to develop moisture reservoir capacity in clay soils against time of drought should employ not only tile drains but also every other known supplementary aid. Among these are included deep tillage, mole drainage, liberal use of such chemical agencies as lime, and, particularly, the systematic growing of deep-rooting crops such as sweet clover and other period crops having relatively coarse tap roots.

Where local economic conditions and scarcity of good crop land seem to stimulate the desirability for development of clay soils by drainage, to be successful such effort should be made on the basis of a long-time investment whose principal return will be some years subsequent to the initial investment and working estimates should be prepared on that basis.

(AUTHOR'S NOTE: The author wishes to acknowledge the advice and assistance in the preparation of this paper given by H. B. Roe, and to the following men for their assistance in furnishing material: L. B. Arnold, Wallace Ashby, L. H. Benton, T. M. Bushnell, C. E. Millar, M. F. Miller, R. S. Smith, and A. R. Whitson.)

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Cities Are Out of Date[1]

WE REGULARLY HEAR the suggestion that the unemployed should be put on the land. A prominent publisher has even urged that Congress appropriate a great sum of money to establish jobless families on the soil, with enough credit to set them up as farmers. We might ask how he would like to have the government set the unemployed up in publishing, to compete with his business. It would be just as fair and perhaps the people would be just as likely to succeed. You can't send people back to the farm who have never been there, and expect them to make good.

American farmers have competition enough now—competition the world around—without encouraging more of it within our own country. We need fewer farmers, not more of them.

We seem to have more people in the cities than are able to take care of themselves. We plainly have too many farmers. So we come up against a very difficult question. How is the surplus of population to find living and security? What is the answer?

There is a solution. While it can not relieve the present emergency, I believe it can be made the basis of progress toward preventing the regular recurrence amongst city workers of the hunger and suffering that are incident to every depression. The answer is the greater diffusion of industry throughout rural America, which would result in less concentration of population in the larger cities.

Once it was almost necessary to establish a factory in a city, because there transportation, fuel, power, labor and markets were readily available. Now, long distance transmission of high voltage electrical current has brought power within reach of nearly every community. The pipe line has taken gas for fuel to many towns. The motor truck and automobile, along with the paved highway, have made transportation elastic. In plain words, the city no longer monopolizes attractions for industry, while the disadvantages of congestion and crowding forever intensify as cities grow larger.

[1]From a radio address on the National Farm and Home Hour by Wheeler McMillen, Associate Editor, The Country Home.

Proposed Standard Design for Kitchen Storage Equipment[1]

By Deane G. Carter[2]

Mem. A.S.A.E.

A PROPOSED SERIES of standard measurements for kitchen storage equipment was discussed in a previous paper[3]. This report suggests a structural method for kitchen equipment which utilizes the minimum number of different items, simplifies construction, is adapted to quantity production, provides an exact construction process, utilizes widely available stock materials, and effects a maximum cost reduction.

In order to reach these objectives a study of this problem was made at the Arkansas Agricultural Experiment Station in cooperation with President Hoover's Conference on Home Building and Home Ownership.

At the present time there are three general types of kitchen equipment for storage: The manufactured units, built-in units from mill or factory-made parts, and units completely built on the job. A wide variety of wood, metal, and composition materials are utilized, and an extreme variation in price is noted for equipment. The construction method presented herewith is adaptable to factory production, or to hand construction on the job. Several types of materials can be utilized in this construction method, although naturally a single type of construction was used throughout the project study.

Stock Used. It was evident from some consideration of possible designs that panel construction, as typically used for cabinet doors, offered the simplest procedure for uniform construction. The panel material selected was a thin, synthetic fiber board pressed into sheets. This material is easily handled, grainless, strong, non-absorbent, and takes paint finishes readily. The standard 48-inch width can be cut with a minimum of waste. Panels were ⅛-inch thick. The same material in either 3/16 or ¼-inch thickness proved suitable for table tops, shelves, and drawer fronts.

Moldings are necessarily uniform in size, easily worked, of light weight, and strong. White pine was selected for these qualities. Since there was no stock molding available in a suitable size or shape, a ¾x1½-inch squared stock was selected as the basic molding material. In addition to the squared stock, the same size material was milled with a groove, and with a lap-joint on one edge similar to shiplap.

[1]Research Paper No. 266, Journal Series, University of Arkansas. Released for first publication in AGRICULTURAL ENGINEERING.

[2]Professor of agricultural engineering, University of Arkansas.

[3]Carter, Deane G. Some Proposed Standard Measurements for Kitchen Equipment. AGRICULTURAL ENGINEERING, Vol. 13, No. 2 (February 1932)

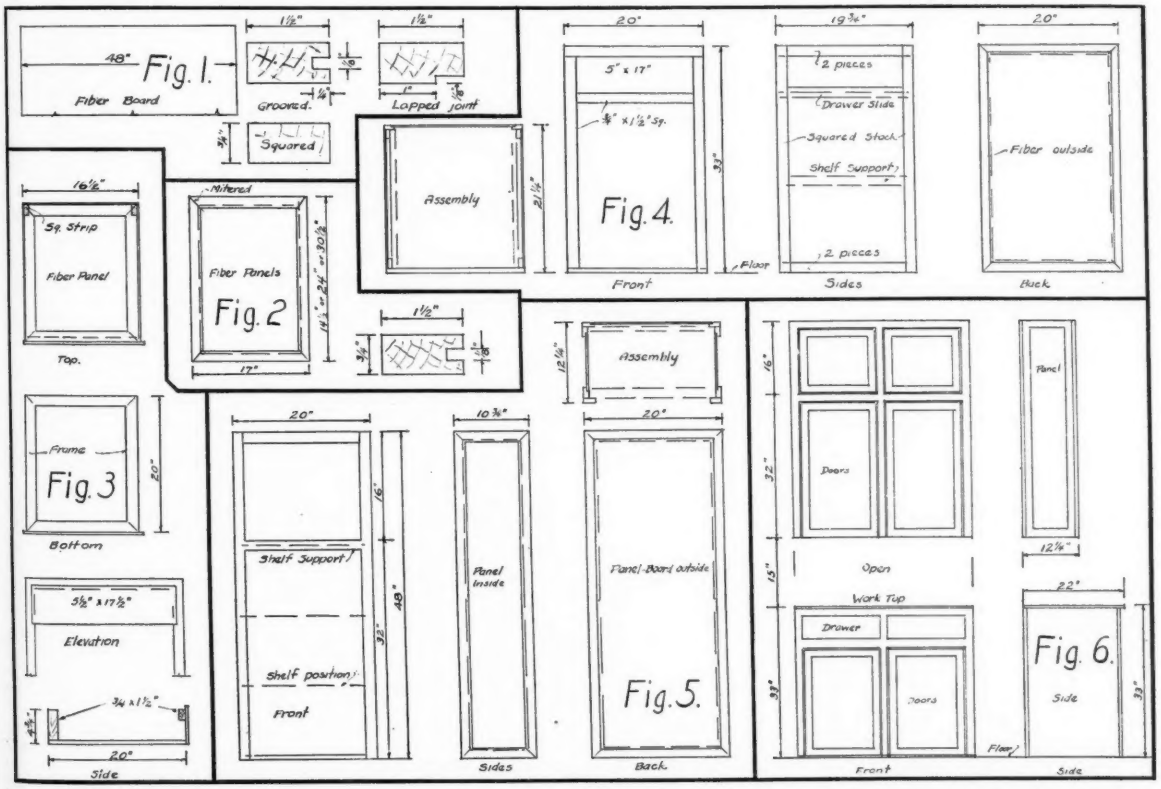


Fig. 1. Items in stock list for cabinet work. Fig. 2. Typical door construction. Fig. 3. Typical drawer construction. Fig. 4. Construction and assembly of base section, standard cabinet (See Table I). Fig. 5. Construction and assembly of single-wall section (See Table II). Fig. 6. Elevation of standard "2-section" cabinet consisting of base and wall sections

Thus the entire cabinet construction consisted of the 48-inch fiber board in ⅛ and 3/16-inch thicknesses and ¾x1½-inch white pine in three forms. Fig. 1 shows the stock list.

Doors. The doors of cabinets represent a principal part of the construction, and are comparatively simple in the proposed design. The ⅛-inch fiber fitted snugly into the ⅛-inch grooves of the molding. Corners were mitered and assembled with corrugated fasteners. In the standard measurements, a single width of door (17 inches) and four lengths are all that are required. Fig. 2 indicates typical door construction.

Drawers. The conventional design for cabinet drawers is not adapted to the use of moldings and panels. In this study a new design was developed, as shown in Fig. 3. The bottom consists of a door panel of the desired size. Sides and front are of fiber board, with molding strips across the front and at the rear corners. This drawer is light in weight and rigid.

Cabinet Fronts. Aside from the doors and drawers, the fronts require only the squared molding to serve as facings around the openings.

Cabinet Backs. Backs may be omitted if the cabinet work is permanently fitted against a finished wall. In the experimental models complete backs were used. Lap-joint moldings with flat panels were used in a manner similar to a "picture frame" method of building.

Cabinet Sides. Typically the sides of cabinets are made exactly like the backs, in panel effect, using the lap-joint molding and fiber board. For base sections, where the panel inset may be objectionable, the sides are made by a frame work of squared stock, with the fiber board outside, forming a flush surface.

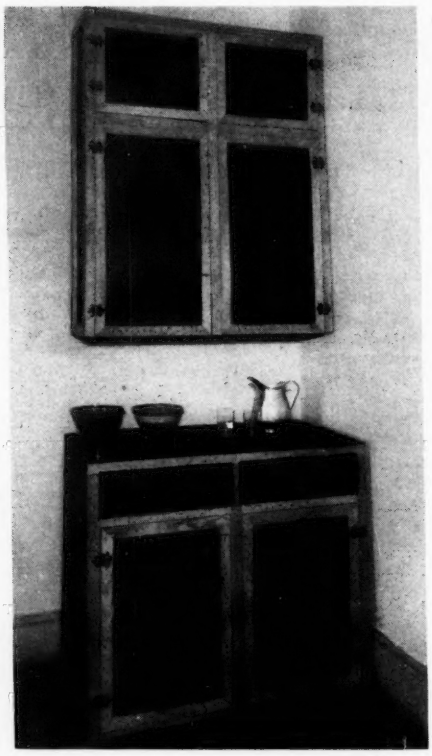


Fig. 7. Laboratory model of double-section wall cabinet

Assembly. When built according to plan measurements, doors, drawers, front, back, and sides may be made separately and assembled. Corrugated fasteners, 4d finish nails, and ¾-inch wire nails were used in the experiment. Shelves and top surfaces were cut from 3/16-inch fiber board. Surface hinges and catches were found the most convenient to attach. The pine molding was used where necessary for drawer sides and shelf supports.

Construction Details. This method of construction may be applied to any of the built-in storage equipment in the kitchen. Base sections, wall cases, broom or storage closets and high storage shelves represent the principal equipment normally required. The method lends itself to an exact listing, and a "precutting" of the materials. Figs. 4 and 5 are detail drawings showing the construction and assembly of a single section of base and wall cabinet. Tables I and II are complete materials lists for the cutting of the stock. It is possible to develop a similar detail and list for each item of cabinet work. Fig. 6 is an elevation drawing of a "double" section which is quite similar to the typical kitchen work cabinet. Fig. 7 shows how the laboratory model looked when completed.

Cost. The retail price quoted for the fiber panel material averages six cents per square foot for the ⅛-inch thickness and seven cents for the 3/16-inch. The moldings, even when specially milled, cost less than two cents per lineal foot. At these prices a work top 24 inches by 6 feet would cost 84 cents. A door 18 inches by 30 inches represents a materials cost of about 36 cents. At prevailing wage rates the cost for all hand labor should not exceed the money cost of the materials. For average and low-cost homes this method should result in a definite reduction in the cost of kitchen cabinet work, in homes where storage equipment is now omitted.

Table I. Material List, Standard Single-Base Section

Dimensions. 20 inches wide; 33 inches high; actual depth, 21¼ inches; work surface, 22 inches deep. Materials consist of ⅛-inch and 3/16-inch fiber board, and ¾x1½-inch white pine in square, grooved, and lapped joint moldings, 4d finish nails, ¾-inch wire nails, and corrugated fasteners on all work.

Use	Materials Required							
	Square		Grooved		Lapped		Fiber Board	Miscellaneous
	Pcs.	In.	Pcs.	In.	Pcs.	In.	Pcs. and Size	
Work top							1—3/16"—20x22	
Front	1—17 1—20 2—31½							
Sides and drawer slides	6—16¾ 6—19¾ 4—33						2—⅛"—19¾x33	
Back					2—20 2—33		1—3/16"—18x31	
Shelf							1—⅜"—16¾x19¾	Shelf brackets
Door			2—17 2—24				1—⅛"—14½x21½	2 hinges 1 catch
Drawer	1—16¼ 2—4		2—16½ 2—20				1—3/16"—5½x17½ 1—⅛"—14x17½ 2—⅛"—4¾x20	

Table II. Material List, Standard Single-Wall Section

Dimensions: 20 inches wide; 48 inches high; depth, 12¼ inches; ceiling height (about), 8 feet. Materials consist of ⅛-inch and 3/16-inch fiber board and ¾x1½-inch white pine in square, grooved, and lapped joint moldings, 4d finish nails, ¾-inch nails, and corrugated fasteners on all work.

Use	Materials Required							
	Square		Grooved		Lapped		Fiber Board	Miscellaneous
	Pcs.	In.	Pcs.	In.	Pcs.	In.	Pcs. and Size	
Front	2—17 2—48							
Sides and shelf braces	6—18½				4—10¾ 4—48		2—⅛"—8½x36	
Back					2—20 2—48		1—⅛"—18x46	
Shelves							4—3/16"—11x18½	4 shelf stops
Doors (2)			2—14½ 4—17 2—30½				1—⅛"—12x14½ 1—⅛"—14½x28	4 hinges 2 catches

SUMMARY

1. The construction method proposed is applicable to all of the usual cabinet work normally used in kitchens.

2. The method is applicable to factory production or to simplified hand work on the job.

3. One size of molding, milled in three shapes, and one type of panel board in two thicknesses constitutes the materials list.

4. Construction may be handled by individual pieces, and assembled into complete cabinets.

5. The method is adapted to an exact material list and precutting.

6. The cost is considerably lower than for conventional types of manufactured or built-in equipment.

Results of 1931 Artificial Drying Studies[1]

By Russell H. Reed[2]

Assoc. A.S.A.E.

THIS PAST YEAR both field and laboratory drying investigations have been carried on to a limited extent by the farm mechanics department of the University of Illinois. The primary object of this work was to assist in solving the rather new and difficult haying problem introduced by the rapid increase in soybean acreage, followed by the present decrease in the prices of soybean grain. Both of these factors have increased the interest in soybean hay to a marked extent.

The shift to this new hay crop has been only partially successful due to the extreme difficulty experienced in field curing soybean hay. This is amply shown by the experience of the dairy husbandry department of the University and of a farmer near Urbana. This past fall the dairy department cut four crops of soybean hay at two-week intervals. The first crop received 0.9 inch of rain, but was ready to be baled in 10 days; the second and third crops received over an inch of rain each, and were in the field approximately two weeks, while the last crop was subjected to four inches of rain and was partly baled at the end of three weeks when it again started to rain. The farmer was not even this fortunate, though he had also gone to the expense of cocking his hay. I happened to ride past his field about six weeks after it had been cut and saw him loading the dried vegetation into racks. At this time the term "hay" could hardly have been used due to the complete loss of color, and the fact that the bottom of each cock was badly molded.

These experiences have led us to feel that the biggest problem at the present time is to make the artificial drying of hay possible on smaller farms. The problem as a whole is simplified by the fact that the average farmer will not go to the inconvenience and expense of drying, except as an emergency practice. Under these conditions a greater expense can easily be justified by the greater potential loss involved.

However, it is quite evident that if the average farmer is to adopt a new practice of this type, he must be supplied with more information on (1) the cost of present haying practices, particularly those used during unfavorable weather conditions, (2) the losses involved in making hay under these conditions, and (3) the effect of artificial drying on the amount and quality of hay produced.

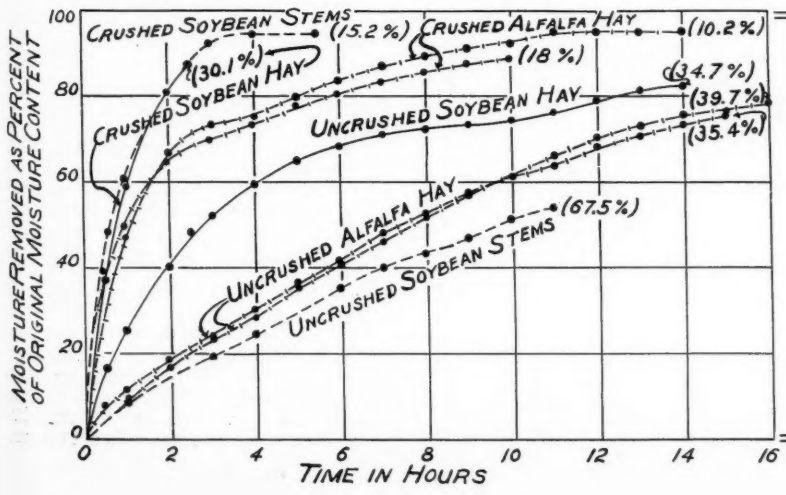
Stack drying has been tried at several stations in this country and abroad, and apparently is successful only where the hay is to be dried and then stored without moving. In Illinois very little hay is stored in stacks, so this necessitated that the stacks be built, dried, loaded, and hauled to the barn.

In 1930 a Mr. Mueller near East St. Louis built several 7x16-foot racks with ventilating cores lengthwise through the middle. He loaded these racks with practically cured alfalfa hay and stored them under a shed for a week or more, where they were protected during the final curing process and where they could accumulate for baling. In this way Mr. Mueller was able to produce hay which commanded a $5 premium on the East St. Louis market.

In view of this experience Mr. Mueller felt that an hour of artificial drying per ton of dry hay would speed up this drying process and produce a better grade of hay. However, when we cooperated with him this spring, the weather was such that the hay had to be left in the field a much longer time to permit its being dried with even three or four hours of artificial drying per ton. As a consequence of this long field curing, the loss of leaves and color was such that no premium could be expected. The plan itself,

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago December 1931.

[2]Instructor in agricultural engineering, University of Illinois.



The effect of crushing on the rate of drying of alfalfa hay, soybean hay and soybean stems. The drying was done at 90 F, and a relative humidity of 32. Figures in parenthesis show moisture content of the material when removed from the drier

however, was much superior to stack drying, since the racks could be at least partly loaded in the field, dried, pulled to the barn, and there baled or unloaded with a fork or with slings.

The length of these racks had the distinct advantage of reducing the thickness of hay through which air had to be forced, and thus reducing the power requirement. This advantage was more than offset, however, by the difficulty experienced in loading the hay so the resistance to air flow would be uniform.

During August and September several changes were made in the portable oil furnace and blower unit. The combustion space was enlarged to 4.5 cubic feet to allow the combustion of up to about 50 pounds of fuel oil per hour; an oil heater was installed to permit the use of 28-30 instead of 38-40 furnace oil; the piping was changed so that the burner could be regulated by adjusting the oil pump pressure; and a valve and outlet was installed in the outlet pipe to allow the smoke and soot to be exhausted while the furnace was being warmed up.

In this connection it was found that from 20 to 30 minutes were required to warm up the furnace to a point at which smoke would not be formed. Even with this preliminary heating, the fuel consumption was abnormally high for the first two to four hours and resulted in a low evaporating efficiency during this time.

A new rack was built to overcome the disadvantages of those previously used. This rack was 9½ feet wide, 14 feet long, and had sloping, slanted sides and ends. A damper was constructed to be used inside the core for deflecting the air to any part of the load not drying properly. This unit was not mounted on wheels as it was to be tried out under practically ideal conditions for loading.

One of the loads dried on this rack weighed 7108 pounds and averaged 52.1 per cent moisture when loaded. Drying was continued for a total of 30 hours during which time the weight was reduced to 4718 pounds, or to an average moisture content of 21.5 per cent. Most of this remaining moisture was found to be concentrated midway between the core and the top of the load, a fault of the method of loading which resulted in the drying being continued longer than was necessary for most of the load. A total of 114 gallons of oil were burned for fuel, and 52 gallons of gasoline were used in the tractor furnishing power. If this fuel oil were purchased at 5.5 cents per gallon and the gasoline at 12 cents per gallon, the per ton cost for these two items would have been $5.30.

We hope to be able to materially reduce the time required to dry these loads as well as the drying cost, by determining the proper size of load, air velocity, and temperature for most economical results. We also feel that a method can be found for dampening the hay immediately surrounding the core and thus eliminating the excessive shattering of this portion during unloading.

During the drying of both the alfalfa and the soybean hay, a caramel odor was quite noticeable. This may be beneficial or it may be detrimental, but in any event it indicates that a definite cooking process is going on in the plant material. There is also an indication that this particular type of cooking is characteristic of a certain temperature or moisture content as it was not noticeably present with the Koon or Arnold driers at Brook Hill Farms, or the new Koon drier at Hoopeston, Illinois.

At the annual meeting of the Society at Iowa State College last June, F. W. Duffee gave some figures we had obtained on the effect of crushing on the rate of drying of alfalfa and soybean hay. Even though a part of the results were given then, it may be of value to elaborate upon them at this time.

This work was intended as a check on the results obtained by the company which invented the new field hay crusher, and to determine, if possible, whether such a machine would have a legitimate place on Illinois farms. As none of these machines were available, a laboratory clay crushing mill was used in the test. This mill had cast iron rolls in place of the rubber rolls I understand the California company is using, which may have accounted for the tendency to strip the leaves from the stems when the rolls were set closer than about 1/32 inch apart.

Progress in the development of equipment and methods for artificial drying of grain and forage crops suggests radical changes in the agricultural map of the United States, favorable to the areas of high summer humidity and rainfall.

As field plants were not available last May, the soybeans and alfalfa were grown in a greenhouse, with the result that the actual values obtained do not represent field conditions, though the relationships should hold quite satisfactorily.

The eight samples of hay were dried at 90 degrees (Fahrenheit) and 32 per cent humidity to represent more or less ideal drying weather. The samples were also spread out on drying racks in such a way as to allow much better ventilation than could be expected under field conditions. Thus the time required for field drying would be at least double or triple that experienced in this investigation.

It was found that the crushed soybean hay dried very rapidly and that in 2½ hours it had reached a moisture content of 30.1 per cent, while the uncrushed sample still contained 34.7 per cent moisture at the end of 14 hours.

The two samples of alfalfa hay dried much slower than the soybean hay, possibly due to the fact that the alfalfa was grown from transplanted roots, and therefore may have had a different type of plant structure than that of the soybeans. The size of the stems also prevented their being crushed to the same extent.

The leaves were picked from a sample of soybean hay to determine the exact effect of crushing. It was found that the crushed stems dried slightly faster than the whole plants. If this proves true under field conditions, a practically ideal situation has been found in which the most valuable portion of the plant can be given the greatest consideration. This is contrasted to the present condition as indicated by the relatively slow rate of drying of the uncrushed stems in comparison to that of the whole plants.

In comparing the soybean stems to one of the samples of alfalfa, it is evident that the main difference is to be found in the leaves, since the uncrushed stems dried slower than the uncrushed alfalfa.

It is against engineering principles to draw conclusions from slight irregularities in the results of a very limited set of experiments. However, it is interesting to note that in four of the eight curves plotted from these drying studies, there is an apparent decrease in the rate of moisture removal when 70 to 75 per cent of the total moisture has been removed, which in these samples represents a moisture content of about 40 per cent. Two of the other four samples were removed before this amount of moisture had been lost, and the two crushed soybean samples dried so rapidly that insufficient weight readings are available to indicate whether such a change took place. It is entirely within the range of possibility that this decrease in rate of drying indicates a chemical or physical change in the plant structure which temporarily retards the loss of moisture.

The nutrition men have not decided the exact stage of maturity at which soybeans should be cut for hay. Assuming that this means that cutting can be carried on over a period of at least a week, there is evidence that a farmer could wait for more or less ideal weather and cure his soybean hay in two or even one day after it had been cut and crushed.

Subsidence and Durability of Peaty Lands[1]

By Wilbur L. Powers[2]
Mem. A.S.A.E.

THE SUBJECT of durability of peat land subsequent to drainage and cultivation was brought clearly to my attention upon the occasion of a visit to the Littleport-Downham Drainage District pumping plant in the English Fens near Ely, when I was informed that the soil surface had subsided 100 inches in as many years. The original pumping plant there was built a century earlier, in 1830, upon a foundation extending below the peat formation. Subsequent search for records, correspondence, and experiments has brought together information which is summarized herein in the hope that it may prove of interest and stimulate further correlated studies of the subject.

Okey[3] cites (Skertchly) to the effect that in 1848 a graduated iron column was sunk in the Fenland near Whittlesay Mere through the peat to solid clay so that its top was the level of the surface. When measured August 25, 1870, subsidence was 7 feet 8 inches and again in 1875 it was 7 feet 9 inches. He further reports that in 1876, one year after erection of pumps made necessary by a total subsidence of 8 feet a drop of 3 inches occurred in one year due to the lowering of the water table. In 1913 the total subsidence was again observed and found to be 10 feet. The initial peat depth was 18 feet. The mean annual compression from nine records of from 9 to 60 years' duration in the Fens is given as 2.2 per cent with a range of from 93 inches in 27 years with an 18-foot depth of peat to 24 inches in 60 years with an initial peatlayer 6 feet deep. The total compression for the nine observations averaged 34.6 per cent.

Moisture control by drainage and cultivation of peat soil may increase the fire hazard, unless supplemental irrigation is included, may hasten oxidation, and cause fairly permanent shrinkage of colloidal constituents upon drying. Liming, regulation of soil temperature, improvement of the nitrogen-carbon ratio, and supply nutrients favor accelerated activities of decomposition microorganisms. Compression may be caused by pasturing animals or by machinery.

Okey et al[3] studied subsidence of peat and muck soils in southern Louisiana and Florida. Records of twenty-two districts with muck from a few inches to 16 feet in depth, and having been reclaimed an average duration of 8 years, indicate an average subsidence of approximately 18 inches. Tests of undrained Louisiana muck show shrinkage of about 60 per cent when dried, and recovery of only 70 per cent of the former volume when resaturated for a long time. As density of the top layer increased, it was observed to check aeration and subsidence.

Dachnowski[4] noted settlement of the surface level of sawgrass peat in the Everglades amounting to 11 to 13 inches in 9 years where the initial depth to bed rock was 8.8 feet. A "highmoor" peat monolith in his office[5] when received from Edewecht, Oldenburg, Germany, 1927, is reported to have measured 13 feet in length and had a moderate moisture content. It is now 7½ feet long.

Wahlberg[5] has reported data from the Santa Ana, Calif., county engineers office showing subsidence of concrete highways on peat land as great as 3¼ feet in ten years.

E. R. Jones, professor of agricultural engineering, University of Wisconsin, has recently advised[5] that the University farm marsh was a floating bog and upon drainage the surface settled approximately 6 inches the first 2 years and 9 inches in 5 years. Since then the settling has been very slow. Recent observations indicate that the subsidence is not more than a quarter of an inch a year. The lines of tile installed at an average depth of 3.7 feet are not now settling appreciably because of the fact that there is no drainage below that level. This bog has been previously described[6] as having peat 1 to 6 feet deep. It was drained in 1910. A 5-foot depth was recommended for tile lines in deep peat.

Zuckerman Brothers, who own and operate extensive areas of peat land in the Sacramento Delta and Lower Klamath Marsh, state[5] "The amount of vertical shrinkage depends on the depth of the peat and our lands near Stockton where the peat averages about 20 feet deep, during the last sixteen years has shrunk approximately 5 feet. At Klamath Falls our land in ten years has shrunk about 2 feet." (This latter area is tule-sedge peat, having an average depth of perhaps 6 feet.)

Professor J. E. Knott of Cornell University writes "There is one piece of muck south of Batavia, New York, which has settled 14 inches in 20 years."

Muck soil near Clatskanie, Oregon, having an initial depth of 7 feet, shrank 18 inches in 10 years following drainage and under cultivation, according to levels referred to a bench mark at the nearby railway station on rocky upland.

The willow-sedge peat in the Lake Labish area near Salem, Oregon, has subsided approximately two feet in two

[1]Oregon Agricultural Experiment Station Technical Paper No. 173, published with the approval of the Director as a Contribution from the department of soils. Released for first publication in AGRICULTURAL ENGINEERING.

[2]Soil scientist, Oregon Agricultural Experiment Station.

[3]Okey, Chas. W. et al, 1918. The Subsidence of Muck and Peat Soils in Southern Louisiana and Florida.

[4]Dachnowski-Stokes, A. P., 1930. Peat Profiles of the Everglades in Florida.

[5]Information furnished by letter.

[6]Elliott, G. R. B., Jones, E. R. and Zeasman, O. R., 1921. Pump Drainage of the University of Wisconsin Marsh.

Table I. Evolution of CO_2 in Treated Willow-Sedge Peat (42-Day Period)

Treatment	Rate, Average Pounds	CO_2 mgrm.	Relative Rate
Check		143	7
KC[1]	200	155	6
K_2SO_4	200	167	5
K_2SO_4 + (Lime 2000)		200	2
K_2SO_4 + (M 20,000)		223	1
K_2SO_4 + M		184	4
Water Logged		40	8
Loam Inoculation	1000	190	3

Table II. Loss (on Dry Matter Basis) in Organic Materials Composted Four Months

Treatment	Sweet clover straw		Flax shoves		Sphagnum peat		Sphagnum moss	
	Loss	Residue	Loss	Residue	Loss	Residue	Loss	Residue
	%	pH	%	pH	%	pH	%	pH
Distilled water	53.9	7.7	11.3	5.9	0.0	4.2	8.0	4.8
Soil and manure infusion	50.4	7.8	11.5	6.0	6.4	4.2	8.5	4.3
Ca*	54.0	8.0	12.6	6.6	3.1	5.2	9.0**	4.8
Ca, N	55.7	8.2	27.0	6.7	10.9	5.6		
Ca, N, K and P	57.5	8.0	29.5	7.1	12.0	4.5	18.2	4.7
N, P, and K (Ca at 60 days)	48.3	8.1	28.7	5.8	10.6	4.8		
Ca, N, K, and P (water logged)	47.5	8.1	25.3	7.2	10.0	4.2	14.0	4.6

*Ca = $CaCO_3$ ppt precipitated 3 per cent
N = NH_4NO_3 precipitated 2 per cent
K and P = K_2HPO_4 precipitated 2 per cent
**No Ca; sweet clover 10 per cent

decades that have elapsed since drainage and approximately one inch of new peat is turned up at each subsequent plowing. This peat ranges from a few feet up to 21 feet in depth. In this locality some loss has been experienced due to the dry furrow slice being floated away by late spring floods.

Gissing[7] states that shrinkage in peat blocks upon drying for industrial use may reduce the size to one-fourth the original volume. It has been estimated that the rate of peat formation is approximately one ton of dry matter per acre or an average of one millimeter depth, per year, at Redkino Peat Experiment Station north of Moscow, U.S.S.R.

A laboratory study[8] was made at the Oregon Agricultural Experiment Station of the effect of different treatments on carbon dioxide evolved from slightly acid willow-sedge peat. Two dozen acid bottles each containing 500 grams of the peat were arranged in duplicate and after various treatments were connected to absorption equipment and aerated intermittently for some six weeks. Results are shown in Table I.

Biological activity correlated with yields in field fertilizer trials and increases in numbers of bacteria per gram found present at the close of the experiment. Fertilizers which increased activity were potassium sulfate, precipitated calcium carbonate, and farm manure, or combinations of these. Results indicate that a little well-rotted manure may serve to inoculate this peat soil and aid decomposition. Drainage and usually supplemental irrigation are desirable for moisture control in these soils.

A study of the rate of decomposition of peat and other organic materials was made the past year in the U.S.D.A. Bureau of Chemistry and Soils in space made available in the soil bacteriology greenhouse at Arlington (Virginia) experiment farm. Duplicate series of stoneware jars were arranged and used as containers for composting (1) sphagnum moss, (2) sphagnum peat, and (3) sawgrass peat, as well as (4) sweet clover straw, and (5) flax "shoves." Various chemicals were added to learn their effect on decomposition and base capacity. Only a summary will be given (Table II) as a more complete report is in press[9].

Observations were made periodically as to rate of carbon dioxide evolution, temperature, reaction and moisture content. Watering, except for water-logged jars, was usually just sufficient to maintain a little free liquid which was drained out by decantation weekly and returned to the top of the material in the jar. Carbon dioxide measurements were for one pair of jars of each series, for only one hour a week.

The sweet clover underwent a "flash" decomposition during the first six weeks, as evidenced by temperature rise and carbon dioxide evolved. Thermograph records show the mean temperature of the greenhouse air was approximately 24 degrees (Centigrade). During the first five weeks sweet clover composts ran temperatures to 4 or 5 degrees above that of the air. Insulation of two flax jars to conserve heat of reaction appeared to aid decomposition. The sweet clover composts lost 47 to 60 per cent of the original organic matter in four months. Decomposition of other materials was slow and ranged from 4 to 30 per cent. The flax had already been retted and was also oily while the acid sphagnum and the sawgrass proved to be resistant to decay.

The sphagnum moss seemed to undergo more active decomposition than did the older sphagnum peat. Sphagnum decomposition appears to have been aided by nitrate additions.

Four one-gallon composts of sawgrass peat were provided for each of three profile layer samples. This material seems to decay very slowly. Neither inoculation nor drainage gave significant results. Addition of nutrients appeared to increase the rate of decomposition during the first two months. Decomposition was most active with soil from the layer 0 to 4 inches from the surface and losses of dry organic matter up to approximately 20 per cent were indicated. The material from the layer 4 to 6 inches from the surface lost about half as much as the fresher surface material, while the older material from the 32-inch layer gave values that were scarcely significant.

CONCLUSION

Settlement of peat appears to be greater during the first years following drainage and the amount of subsidence will depend on depth of drainage as well as depth and composition of peat. Also, erosion by wind or water may cause loss of dry peat. The organic colloids shrink greatly upon drying and seem to be partly irreversible or to only partly recover colloidality upon long contact with water. Control of fires, moisture, temperature, aeration, reaction and nutrients required by decomposition microorganisms afford means of regulating somewhat the rate of decomposition of peat. Drainage should be designed to provide for vertical shrinkage of the order of 33 per cent. It is hoped that permanent bench marks may be established in important peat areas for reference in obtaining vertical shrinkage data in the future.

[7]Gissing, Fred T., 1920. Peat Industry Reference Book.

[8]Powers, W. L., 1930. Chemical Characteristics of Peat Soils in Northwestern United States. In Press Proc. 2nd International Congress of Soil Science.

[9]Powers, W. L. Characteristics of Colloids from Peaty Soils. In press, J. Agri. Research.

The Economics of Engineering[1]

AFTER ALL, in the broader sense of the terms, is not engineering just one branch of the general subject of economics? The dictionary defines economics as "the science that investigates the conditions and laws affecting the production, distribution and consumption of wealth, or the material means of satisfying human desires." Certainly, engineering is a large factor in the "production and distribution" of wealth, if not in its consumption, and it has a most important influence on the "means of satisfying human desires."

The newspaper and magazine writers of the day are wont to say that we are living in a scientific and engineering age, which is undoubtedly true, but it is not so much emphasized that we are living in a commercial age. There are few enterprises today that do not have to stand the "dollar test" and earn "a return" on investment. There are very few strictly monumental structures being built in this day. The temples of ancient Greece and the cathedrals of the Middle Ages have all been built, but such is the force of tradition that many architects are still trying to copy them. . . . . The more advanced architects are beginning to realize that it is possible to house the economic and industrial requirements of an enterprise in a building of fine proportions and graceful lines, and with simple, straightforward decorations, without sacrificing any of the utilitarian requirements.

From a practical point of view, the economics of engineering become largely a matter of recognizing the importance which the "fixed charges on the investment" bear to the ultimate value of the enterprise. In the industrial activities of the day, as methods of production become more refined—whether it be manufacturing processes or the production and distribution of electric power—the investment in plant and equipment becomes an increasing factor in the cost of the finished product. In manufacturing, our methods of quantity production have reduced the cost of raw materials and labor, and have increased the cost of plant and the consequent items of fixed charges. In our electric power stations, as our technical knowledge and experience have improved, we have considerably reduced the cost of fuel and labor, but it has been very difficult greatly to reduce the fixed charges because the cost of the more elaborate and refined technical equipment has nearly offset the reduction in costs that could be effected by the increasing size of units and by reduction in building requirements per unit of capacity.

[1]From a paper on this subject by Wm. S. Monroe in the February 1932 issue of the Journal of the Western Society of Engineers.

Some Factors Affecting the Economic Use of Tractor Engines at Part Loads[1]

By E. G. McKibben[2] and A. P. Aglibut[3]

Mem. A.S.A.E.

MANY FARM TRACTOR ENGINES are frequently operated for considerable periods at appreciably less than their rated power. This is especially true in the general farming area. From the viewpoint of stationary or power plant engineering, this is often considered an uneconomic practice. However, this attitude should not be taken unless a careful investigation of all the facts involved shows it to be justified, for there are many situations under which this practice is justified or can be made justifiable by the proper management of the engine.

There are at least three factors which tend to require the partial load operation of farm engines, including tractor engines:

1. The wide range in power requirements of farm power operations
2. The scattered location of many farm power operations
3. The low load factor (hours per year) of many farm power operations.

While it is admitted that these factors are reduced to the economic minimum on a well-managed farm, they are at present a very important part of the power situation on most diversified farms.

Therefore, the farm operator must decide to what extent he will use the tractor engine for operations requiring only a small per cent of its power, and whether or not under the given conditions he will purchase a smaller engine to supplement it. If this decision is to be made on an economic basis at least the following factors must be considered:

1. The relative fuel requirements of the large and small engines while performing the given operation.
2. The cost of fuel per gallon
3. The overhead or fixed charges on the supplementary engine
4. The hours of operation at the given power per year.

Of course there are other factors not so distinctly economic, such as the automotive ability of the tractor engine, and the fact that employees are already familiar with the operation of the tractor engine.

FUEL REQUIREMENTS

The following discussion and the curves presented are based on the use of gasoline of approximately the following characteristics: Specific gravity, 0.732; Baume, 61 degrees; pounds per gallon, 6.1; gallons per pound, 0.164; on the results of tests conducted at Iowa State College; on the published results of recent Nebraska tractor tests, and on characteristic curves supplied by manufacturers.

The upper curve of Fig. 1 shows about what may be expected of a tractor engine at various percentages of rated load when operated at rated speed and with the carburetor set for rated speed and rated power. Of course, because of varying and uncontrollable conditions, the results obtained in any given case may vary greatly from this curve, often as much as 10 per cent over the whole curve and occasionally as much as 20 per cent over the less-than-half-load section.

The lower curve of Fig. 1 shows results that may be obtained at various percentages of rated power when operating at optimum speed (lowest speed at which engine will satisfactorily develop the required power) and optimum carburetor setting for the required power. As with the upper curve, the results obtained in any given case may vary considerably from this. However, with a well-designed, variable-speed engine, properly adjusted under satisfactory operating conditions, these results could reasonably be expected.

Note that under these conditions there is no increase in fuel consumption per horsepower-hour down to 75 per cent of rated power. In many cases the fuel requirement per horsepower-hour at 75 per cent of rated power will be less than that at rated power, and that at 50 per cent of rated power will be no greater than that at rated power.

Operating at rated speed with optimum carburetor setting, or operating at optimum speed with the carburetor left at the rated speed, the rated power setting will give results between these curves. Since there could be an infinite number of these situations, only the extremes as represented by these curves will be considered.

The difference between these curves of Fig. 1 and the straight line through 0.7 pound represents the loss in excess fuel over the requirements of an equally efficient supplementary engine selected for the given load. This loss must be balanced against the overhead cost of owning a substitute engine.

The value of the difference between the two curves of Fig. 1 represents the amount which may be spent to obtain optimum speed and carburetor adjustments, as by a more skillful operator and new pulleys for machines of low power requirement.

[1] A paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago December 1931.

[2] Associate professor of agricultural engineering, Iowa State College.

[3] Graduate student, department of agricultural engineering, Iowa State College.

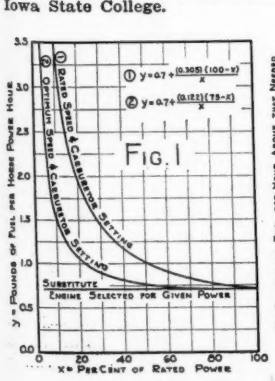


FIG. 1
① Rated Speed & Carburetor Setting
② Optimum Speed & Carburetor Setting
Substitute Engine Selected for Given Power
y = Pounds of Fuel per Horse Power Hour
x = Per Cent of Rated Power

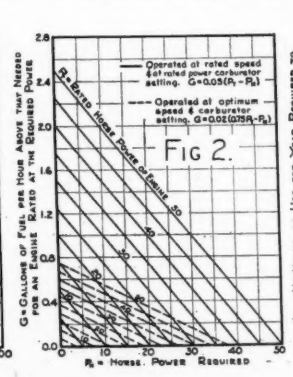


FIG 2.
Operated at rated speed & rated power carburetor setting.
Operated at optimum speed & carburetor setting.
R = Rated Horse Power of Engine
G = Gallons of Fuel per Hour Above that Needed for an Engine Rated at the Required Power
Pr = Horse Power Required

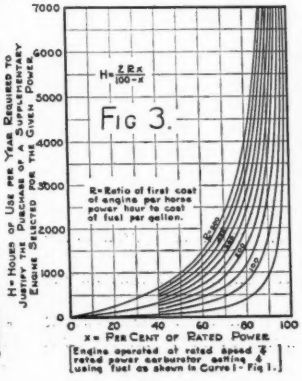


FIG 3.
R = Ratio of first cost of engine per horse power hour to cost of fuel per gallon.
H = Hours of Use per Year Required to Justify the Purchase of a Supplementary Engine Selected for the Given Power
x = Per Cent of Rated Power
Engine operated at rated speed & rated power carburetor setting & using fuel as shown in Curve 1 - Fig 1.

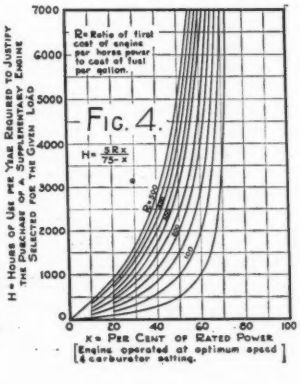


FIG. 4.
R = Ratio of first cost of engine per horse power to cost of fuel per gallon.
H = Hours of Use per Year Required to Justify the Purchase of a Supplementary Engine Selected for the Given Load
x = Per Cent of Rated Power
Engine operated at optimum speed & carburetor setting.

Fig. 2 shows the excess fuel in gallons per hour required for different power needs when met by tractor engines of various power ratings instead of an engine rated at the needed power. These curves are developed from those shown in Fig. 1. The solid curves are for operation at rated speed and at rated power carburetor setting. The broken curves are for optimum speed and carburetor setting.

Figs. 3 and 4 show the hours of use per year required to justify from an economic standpoint the purchase of an additional engine under the indicated conditions of ratio of needed power to rating of available engine and of ratio of first cost per horsepower of a supplementary engine to fuel cost per gallon. Fig. 3 assumes the operation of the available engine at rated speed and at rated power carburetor setting, and Fig. 4 the operation of the available engine at optimum speed and carburetor setting. Both figures are based on the curves of Figs. 1 and 2 and on the assumption that the yearly cost of use (depreciation, interest, housing, insurance, and taxes) of the supplementary engine would be 10 per cent of its first cost, more than the cost of the additional maintenance and depreciation on the available engine if it were used instead of purchasing the supplementary engine.

SUMMARY

1. Figs. 1 and 2 indicate the possibility of considerable saving by the proper adjustment of speed and carburetor for partial load operation.

2. A study of Fig. 3 indicates that even as usually operated at or near rated speed a tractor engine can be economically used under present price conditions for many short-time operations requiring only a relatively small proportion of the rated power. For example, with a ratio of engine cost per horsepower to gasoline cost per gallon, of 300, it would require 400 hours of operation annually of a 30-horsepower engine at 12 horsepower, or 40 per cent rated load, to justify the purchase of a supplementary 12-horsepower engine.

3. Fig. 4 shows the increased possibilities of the economic use of the tractor engine for partial load operation if the speed and carburetor are properly adjusted. With a ratio of engine cost per horsepower to fuel cost per gallon of 300, it would take 200 hours of operation annually of a 30-horsepower tractor engine at 10 per cent (3 horsepower) of rated power to justify the purchase of a supplementary 3-horsepower engine on the basis of fuel saved.

4. The above facts suggest that more attention might be profitably given to the design of governors and carburetors for variable speed and load operation.

5. The possibilities of increasing part-load efficiency by operation at decreased speed should receive due consideration from designers when selecting belt speeds and gear ratios.

6. It might also be of value to furnish salesmen, service men, and dealers with more information concerning the engine characteristics of the tractor in which they are interested.

7. There may be some merit in considering the possibilities of using medium-powered auxiliary engines such as those found on combines as stationary or semi-portable power plants when not needed on the combine. Proper adjustment of speed and carburetor would permit their economic use for rather light loads.

8. The authors wish to emphasize that they are not advocating the use of only one engine where two are needed. Their purpose has been to call attention to the economic possibilities and limitations of the use of tractor engines at partial loads, under conditions where such use may seem desirable.

EQUATIONS

In the semi-empirical equations which are given below for Figs. 1, 2, 3, and 4

C_e = first cost of supplementary engine per horsepower
C_f = cost of fuel per gallon
G = gallons of fuel per hour in excess of that needed by a supplementary engine rated at the required power
H = hours of operation annually required for the economic justification of the purchase of a supplementary engine
P_n = horsepower needed for given operation
P_t = rated horsepower of available tractor engine
R = ratio of first cost per horsepower of a supplementary engine to cost of fuel per gallon
x = power needed expressed as per cent of rated power of available tractor engine
y = pounds of fuel per horsepower-hour

The upper curve of Fig. 1 is approximately represented by the equation

$$y = 0.7 + \frac{(0.305)(100 - x)}{x} \quad \ldots\ldots [1]$$

and the lower curve of Fig. 1 is approximately represented by the equation

$$y = 0.7 + \frac{(0.122)(75 - x)}{x} \quad \ldots\ldots [2]$$

These equations are limited to values of x less than 100 and 75, respectively.

The solid and broken curves of Fig. 2 may be represented by the equations

$$G = 0.05\,(P_t - P_n) \quad \ldots\ldots [3]$$

and $$G = 0.02\,(0.75P_t - P_n) \quad \ldots\ldots [4]$$

respectively. These equations are limited to conditions where P_n is less than P_t and 0.75 P_t, respectively.

Equation 3 is developed from Equation 1 as follows: From Equation 1 the excess fuel in pounds per horsepower-hour is $[(0.305)(100 - x) \div x]$. Dividing this by 6.1 reduces is to gallons per horsepower-hour, or $[(0.05)(100 - x) \div x]$. Multiplying by P_n gives $[(0.05)(100 - x)P_n \div x]$, which is equal to G. Therefore,

$$G = \frac{(0.05)(100 - x)P_n}{x} \quad \ldots\ldots [5]$$

In equation (5), $[(P_t - P_n) \div P_n]$ may be substituted for $[(100 - x) \div x]$. If this is done and the equation reduced to its lowest terms, it becomes Equation 3. Equation 4 is developed from Equation 2 in a similar manner.

The equations for the curves of Figs. 3 and 4 are

$$H = \frac{2Rx}{100 - x} \quad \ldots\ldots [6]$$

and $$H = \frac{5Rx}{75 - x} \quad \ldots\ldots [7]$$

respectively. These equations are limited to conditions where x is less than 100 and 75, respectively. These equations are developed from the empirical curves and equation of Fig. 1; the assumption that the additional annual overhead resulting from the purchase of a supplementary engine will be 10 per cent of its first cost; and the following general statement, that the number of hours of use annually required to justify the purchase of a supplementary engine is equal to the additional overhead per horsepower of the supplementary engine divided by the fuel saving per horsepower-hour resulting from the purchase of the supplementary engine. From Equation 1 the excess fuel in pounds per hour per horsepower is $[(0.305)(100 - x) \div x]$. This divided by 6.1 gives the excess fuel in gallons per hour per horsepower, or $[(0.05)(100 - x) \div x]$.

Therefore, from the general statement given above

$$H = \frac{0.1C_e}{\frac{(0.05)(100 - x)\,C_f}{x}} \quad \ldots\ldots [8]$$

If R is substituted for $(C_e \div C_f)$ in this equation and the equation reduced to its simplest terms, it becomes Equation 6 above. Equation 7 is developed in the same manner.

A Study of Tractor Stop-Hitches[1]

By Arthur W. Clyde[2]
Mem. A.S.A.E.

FIELDS CONTAINING solid stones, stumps or roots near the surface can be plowed with two or three well-trained horses and a walking plow without very great breakage of plows and with little loss of time. When a larger power unit is used, whether it be more horses or a tractor, it becomes almost essential with present plows to provide some kind of cushion or overload release hitch. The kinetic energy of the power unit is so great at common speeds that, if it is stopped suddenly, an extremely large force must be applied to it. For example, a 4000-pound tractor going 3 miles per hour might have kinetic energy of over 16,000 inch-pounds. Suppose it is pulling a plow which strikes a solid rock and that the hitch and beam stretch enough to let the tractor move one inch in stopping. Even though the tractor clutch had been released, an average force of nearly 16,000 pounds would be exerted on the plow with the maximum force being almost double that. Needless to say, a single plowshare, frog, or beam, will hardly stand that force. The common type of spring overload release hitch, if kept properly adjusted, gives good protection to a two-bottom plow with steel shares and fair protection to cast shares. It is improved if combined with a handle so that the tractor driver can recouple the plow from the seat as shown in Fig. 1. Its drawbacks are (1) the temptation for an inexperienced driver to "ride the clutch" so he can stop promptly after the release operates, and (2) the time lost in stopping, backing and recoupling.

There are two types of stop-hitches which show promise of overcoming the above drawbacks of the common overload release, and of being practicable.

Type I. Overload Release Hitch with Cluth Throwout. When the plow strikes a solid obstruction, the hitch uncouples the tractor from the plow and immediately declutches the tractor. The hitch parts do not fall to the ground but are held up by a guide or guides on the tractor. After the tractor stops, the operator backs up and the hitch recouples.

Figs. 2 and 3 show a device of this type. A is an overload release which transmits the tractor pull to the plow through B by hooking with K. When A releases, a pull is applied to rod L and thereby to trigger E. Spring G and lever F then declutch the tractor. In this particular device as tested, guide rods C permitted the tractor to coast freely about 20 inches away from the plow. If the tractor did not stop in that distance, it struck stop pins D a blow of some severity. Pins D are connected to the plow. Therefore, the blow goes to the plow. As will be explained later, a stopping distance of more than 20 inches is often needed to avoid damage to the plow share by this blow. Springs, dashpots, or brakes, could, of course, be used with this device to assist in stopping the tractor. It is likely, however, that with this type of stop-hitch it will be more economical to depend mainly on enough stopping distance rather than on springs, dashpots, etc.

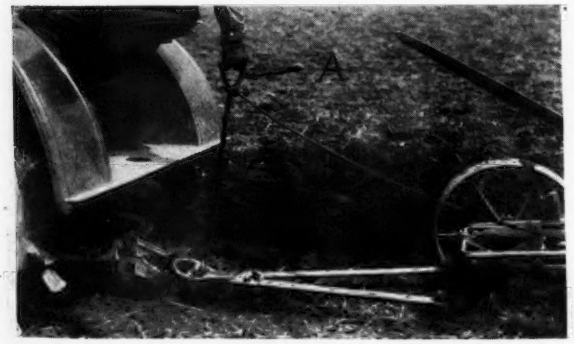


Fig. 1. A common overload release hitch. Handle "A" permits recoupling from the seat

Type II. Drawbar Cushion Spring with Clutch Throwout. The tractor pull is transmitted to the plow through a spring. When the pull exceeds a certain value, the deflection of the spring actuates a clutch trigger and declutches the tractor. The spring then has enough additional capacity to absorb the kinetic energy of the tractor as it stops without exerting more than some certain force on the plow. E. G. McKibben[3] last year discussed the advantages of the clutch release in this connection and gave results of tests. Those tests and their analyses convince me that a hitch of this type must permit the tractor to travel several inches after it is declutched, if the stopping force on the plow is to be kept low enough to prevent damage when plowing is done at about three miles per hour. This introduces the rolling resistance of the tractor as a factor and explains why a different method of analysis is used later in this paper.

DYNAMICS OF STOPPING A DECLUTCHED TRACTOR

A moving tractor has kinetic energy due to its forward motion which must be overcome in slowing down or stopping. If W = weight in pounds and S = speed in miles per hour, this energy is $0.4008\ WS^2$ inch-pounds. In addition to this, the wheels and transmission parts have energy due to their rotation. If only the wheel rims and lugs are considered and slippage is neglected, this can be shown to be $0.4008\ LS^2$, in which L is the weight of the rims and lugs including both front and rear wheels, and S is the speed as before. Each pound of weight in rims and lugs, therefore, contributes doubly. It contributes its share to the energy due to forward motion and contributes an equal amount due to rotation. Thus, if the rims and lugs are 10 per cent of the total tractor weight, their rotational effect can be included by adding 10 per cent to $0.4008\ WS^2$. The effect of spokes and hubs is smaller, each pound of spokes having only about one-fourth as much energy due to rotation as a pound in rims and lugs. Hubs, shafts, and gears are still less effective because of their smaller radius of gyration. Probably about 2 per cent might cover them, the spokes, and a slight amount of slippage.

It is, therefore, of interest to know how much of a tractor's weight is in the wheel rims and lugs. In several tractors with two drivewheels this varies from 8½ to 15½ per cent, depending largely on rim and lug equipment. The weight of tracks and wheel rims on track-type tractors is figured in the same way. The weight of tracks for several machines has been obtained and found to be from about 16 to 24 per cent of the weight of tractor and operator.

The total kinetic energy for any tractor is, therefore,

$$\left(1+\frac{m}{100}\right)\ 400.8\ \frac{W}{1000}\ S^2$$

in which m is the per cent of weight in rims, lugs, or tracks plus about 1 or 2 per cent for spokes, hubs, shafts, etc. For each 1000 pounds of tractor weight including operator, the energy is CS^2 in which C is a coefficient having values as follows depending on wheel and lug equipment:

[1]Publication authorized by the director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 551. Released for first publication in AGRICULTURAL ENGINEERING.

[2]Research agricultural engineer, Pennsylvania State College.

[3]McKibben, E. G. "The Combination Cushion Spring and Clutch Release Hitch." AGRICULTURAL ENGINEERING, Vol. 12, No. 3 (March 1931) pp. 87-88.

For two-wheel-drive tractors, C = 440 to 465
(10 to 16 per cent added for rotation)
For track-type tractors, C = 465 to 495
(16 to 24 per cent added for rotation)

Tractor motion is opposed by rolling resistance and by friction of moving parts. The average value of this force per 1000 pounds of machine (hereafter simply called "resistance") will be termed r. On level ground as soon as the clutch is thrown out this force times the distance through which it operates is work absorbing the kinetic energy. If the tractor travels d inches after declutching and the kinetic energy still remaining in it is called k, then

$$k = CS^2 - rd \qquad [1]$$

When d is great enough to make $rd = CS^2$, the value of k is zero, and the tractor stops. The stopping distance of the unloaded tractor on level ground may, therefore, be used to compute r for that ground, provided d is measured with reasonable accuracy.

When a tractor goes down hill, there is a component of its weight acting down hill which opposes the resistance and increases the stopping distance as compared to level ground. On ground having a slope of f feet per 100 feet, this component is

$$(Wf \div \sqrt{100^2 + f^2})$$

The value of $(f \div \sqrt{100^2 + f^2})$ for several slopes is as follows:

Per cent slope	f	Per cent slope	f
2	0.02	12	0.1193
4	0.04	14	0.1386
6	0.0599	16	0.158
8	0.0797	18	0.1772
10	0.0995	20	0.1961

The general equation for each 1000 pounds of tractor weight on either level ground or a downhill slope is, therefore,

$$k = CS^2 - d\left(r - \frac{1000f}{\sqrt{100^2 + f^2}}\right) \qquad [2]$$

in which

k = kinetic energy remaining in the tractor in inch-pounds per 1000 pounds weight
C = coefficient depending on wheel or track equipment
S = speed at instant of declutching, miles per hour
d = distance travelled after declutching, inches
r = resisting force in pounds per 1000 pounds weight due to rolling resistance, axle friction, etc.
f = slope of ground, feet per 100 feet.

On the slopes usually encountered $(f \div \sqrt{100^2 + f^2})$, the sine of the grade angle, is about the same as $(f \div 100)$, the tangent of the angle. Only slight error is introduced, therefore, if Equation 2 is simplied into

$$k = CS^2 - d\,(r - 10f) \qquad [3]$$

Equation 3 is shown graphically in Fig. 4. Suppose it is desired to find k when $S = 3$, $f = 4\frac{1}{2}$, $r = 150$, and $d = 20$. This is shown by the dotted line starting on the left where f is $4\frac{1}{2}$. This line is carried to the right until it meets the diagonal for $r = 150$. From this point proceed vertically (up or down as necessary) until the diagonal for $d = 20$ is met. Then go to the right until reaching the vertical line for $S = 3$. This shows $k = 2000$ inch-pounds energy remaining in the tractor per 1000 pounds weight. Following down the k line shows the speed to be about 2.1 miles per hour after 20 inches. It also shows that if S had been 2.15, k would have been 0, thus showing that the tractor would have stopped in 20 inches on the same slope if its speed had been 2.15 instead of 3 miles per hour.

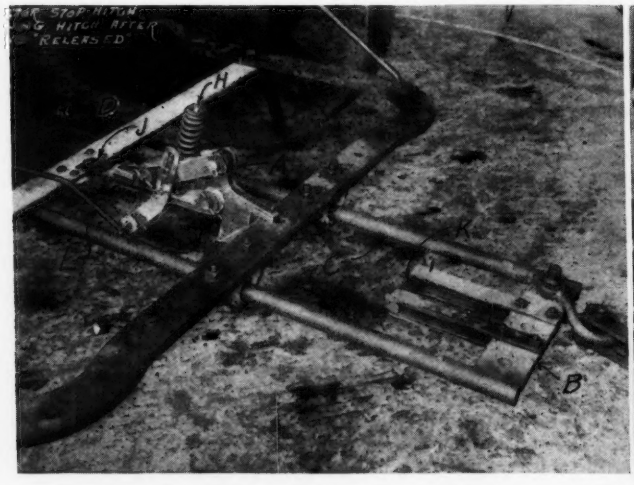
By partly reversing this process it is possible to find what value of d, r, or f will stop the tractor when all other variables are known. For example, let S be $3\frac{1}{2}$; f, 0 (level ground); and r, 150. By going left from where k is 0 and S, $3\frac{1}{2}$, also going up from where f is 0 and r, 150, it will be found that d is about $37\frac{1}{2}$ inches.

The practical application of this is twofold. If the tractor is to be allowed to coast until it stops, the curves can be used to get the stopping distance for different speeds, grades and resistances. If the stopping distance is to be limited, the curves show the amount of energy still contained in the tractor after any given free travel, and calculations can then be made for springs or other devices to absorb that energy without imposing more than some maximum force on the plow.

It should be noted that Fig. 4 is for $C = 457$. This was the coefficient of the tractor used in the field tests with a Type I hitch. The two drivewheels were equipped with 8-inch overtires on 6-inch rims which would be about equal in weight to extension rims. The rims and lugs were about 12 per cent of the weight of tractor and operator. Allowing 2 per cent more for front wheel rims, spokes, shafts, etc., gives a total addition of 14 per cent for rotation, making C, 457. For other values of C it is necessary only to shift the k lines on the chart. New k lines can be located by finding what values of f will make k = 0, 1000, 2000, etc., using the new value of C and some assumed values of d, r and S.

FIELD TESTS WITH TYPE I HITCH

A sod field was selected for the field trials. The ground was rather dry and firm, thus giving about as low a value



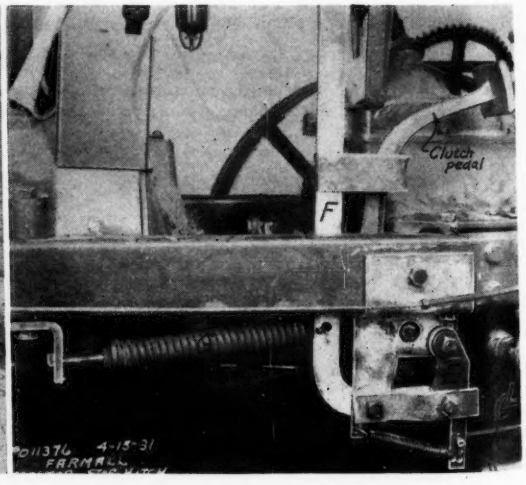
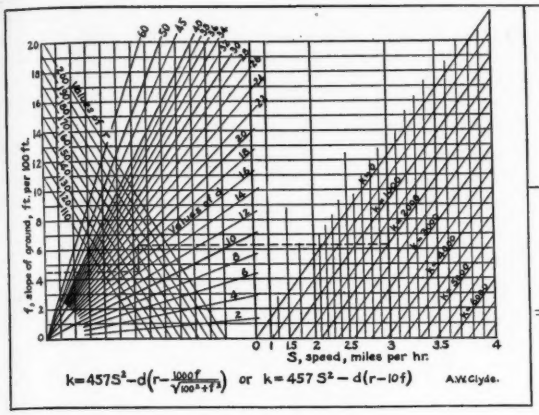


Fig. 2. (Left) A Type I stop-hitch. Fig. 3. (Right) Clutch trigger and throwout for operation with the same type of hitch



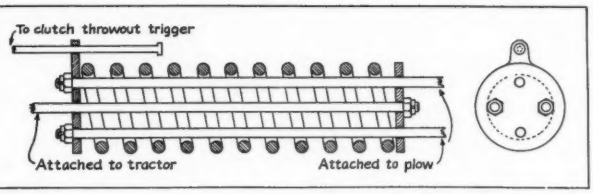


Fig. 4. (Left) Chart showing the relations of speed, stopping distance, slope, resistance, and kinetic energy of a typical tractor. Fig. 5. (Above) A Type II stop-hitch. A clutch trigger and throwout similar to those shown in Fig. 3 might be used with it

of r as would be encountered in plowing. A hitch satisfactory on sod would have an easier task on a soft field because the higher resistance would stop the tractor more quickly. First a chisel was used as a load, and later a two-bottom plow.

The first trials were to measure the actual stopping distance. The release was set to act frequently in stone-free ground and the travel of the tractor after declutching measured on guide rods C (See Fig. 2). Stop pins D were removed so they would not restrict the travel. The tractor and operator weighed 4200 pounds. The results on level sod were as follows:

	First gear	Second gear
Speed of tractor, miles per hour.....	2.25	3.10
Kinetic energy per 1000 pounds, CS^2..	2320.00	4390.00
Stopping distance d, average of 14 and 21 trials, inches	15.93	28.75
Value of r, using above d	145.00	154.00

Another method of finding r was to find a slope down which the tractor alone would continue in uniform motion after declutching. This grade was found to be about 16 per cent, giving a value of $r = 158$. Still other trials were made by towing the tractor and measuring the pull with a dynamometer. By this method r was from 147 to 158.

Other trials were made with actual plowing in second gear on level ground with stop pins D in place to limit the travel to 20 inches. Fig. 4 shows that after going 20 inches the tractor still had about 1200 inch-pound energy per 1000 pounds, corresponding to a speed of 1.7 miles per hour. Two cast shares were soon broken, indicating that the blow on the stop pins was too severe. It would, of course, be intensified when going down hill. The guide rods will be lengthened to permit about 42 inches of travel as needed when going down a 5 per cent grade at 3.1 miles per hour.

An interesting possibility was shown in experimenting with spring to reduce the stopping distance. A spring between the plow and tractor, when adjusted with no slack, would on level ground usually pull the tractor back and recouple it automatically after the hitch had broken.

USE OF SPRINGS WITH TYPE I STOP-HITCH

As suggested above, one or more springs may be added to reduce the stopping distance or to make the hitch recouple. They may be arranged to act as soon as the hitch breaks or they may permit some free travel before acting. In either case, Fig. 4 may be used to assist in designing the springs. Since the work done by all resistances must equal the energy of the tractor, this relationship can be expressed by the equation

$$k = x\left(\frac{p}{2} + r - 10f\right), \text{ or } x = \frac{k}{\frac{p}{2} + r - 10f} \qquad [4]$$

in which

x = total spring deflection, inches

p = maximum load on springs per 1000 pounds tractor weight

k = is taken from Fig 4 using the free-coasting distance as d.

If the springs begin to act as soon as the tractor is declutched, k is the original energy, CS^2.

It seems probable that the additional cost of springs may limit their use in this connection and that the Type I hitch will depend mainly on enough stopping distance.

DESIGN OF TYPE II STOP-HITCH

A simple form of a Type II hitch is shown in Fig. 5. The rod loading to the clutch release trigger is adjusted in length so that an abnormal pull, as would be caused by striking an obstruction, will pull the trigger and cause the tractor to be declutched. As the tractor stops, its energy is absorbed by further spring deflection, and after the tractor has stopped, the spring will pull it backwards. The tractor is never free from its load, and no time is lost shifting gears to recouple.

The spring may be designed on the basis that the work of all opposing forces after declutching will equal the kinetic energy of the tractor. For a 1000-pound tractor

$$CS^2 = d'\left(\frac{p + p'}{2} + r - 10f\right)$$

or

$$d' = \frac{CS^2}{\frac{p + p'}{2} + r - 10f} \qquad [5]$$

in which d' = distance required to stop tractor, inches

p = final force on the spring per 1000 pounds of tractor weight

p' = force on spring when tractor is declutched per 1000 pounds of tractor weight

C, S, r and f are as in Equation 2.

The spring is ready deflected by p', therefore, the total spring deflection is $[\, d'\, p \div (p - p')\,]$. The number of acting coils needed in the spring may then be obtained by dividing the total deflection by the permissible deflection per coil for the spring selected. It should be noted that d' is independent of tractor weight but that p, p', C and r are for each 1000-pound weight.

As an example, suppose that a spring is to be chosen for a 4200-pound tractor going 3.1 miles per hour down a 5 per cent grade. Tractor and soil characteristics are such that $r = 155$ and $C = 457$, giving kinetic energy CS^2, of 4,390 pounds per 1000 pounds of weight. The tractor is to declutch at a 2000-pound pull, or 477 pounds per 1000 pounds of weight, and the maximum force on the spring (and plow) must not exceed 4000 pounds, or 953 pounds per 1000 pounds of tractor weight. Substituting these values in the formula gives d' as about 5.4 inches, and the total spring deflection about 10.8 inches. A 4000-pound spring would be used. A spring of 13/16-inch wire and a pitch diameter of 5¼ inches might be selected[4]. The allowable deflection per coil being 1.08 inches, ten acting coils would be needed. Its free length would be about 21 inches. Two springs in

[4] "Kent's Mechanical Engineers' Handbook," 10th edition, p. 1561.

parallel, of 9/16-inch wire and 3⅞-inch pitch diameter, would give about the same result with 12½ acting coils each. Another possibility would be a nest of springs, a small one inside a large one.

SUMMARY OF DESIGN CONSIDERATIONS

With either type of hitch, the designer must first decide the speed and grade against which protection will be given. Many tractors now plow at a little over 3 miles per hour. Probably the stop-hitch should permit this speed down a 5 per cent slope, relying on the operator to reduce speed on steeper slopes where there may be danger of striking stones.

Several methods of checking indicate that the method given for computing kinetic energy is fairly accurate, if the proper value of C is chosen. This depends largely on the weight of rims and lugs or tracks with which the tractor is equipped. With present machines it will range from 440 to 495.

The value of r for firm sod ground varies considerably for different tractors. Tests by the three methods of towing, measurement of stopping distance, and coasting grade give values from 145 to 185 for a few two-wheel-drive machines. Probably 150 to 155 might be reasonable for most of them. Tests with one track-type machine gave a value of about 110 because of decreased rolling resistance. Calculations based on the Nebraska tests indicate, however, that one tractor of the wheel type has a value of r as low as or lower than this tracklayer.

It will be noted that high drawbar efficiency as shown by a low value of r puts a greater demand on a stop-hitch. For example, on a 5 per cent slope at 3.1 miles per hour a typical wheel tractor would need a stopping distance of 42 inches and a typical tracklayer about 75 inches. This might make a Type II hitch the only practical one on the tracklayer.

When the springs exerting force on the plow are used to stop the tractor, there is some limit to the force which they should exert. There is little information available about the force required to break a plow share, but tests at this station seem to show that most cast shares can withstand a force of about 3,000 pounds, while steel shares were not damaged by forces from 4,000 to 5,000 pounds. Until more trials are made these figures are probably the best ones to use as the maximum for springs used in stop-hitches.

Size of Rooms in Five-Room Ready-Cut Houses[1]

By Dan Scoates[2]
Mem. A.S.A.E.

THIS article will discuss sizes of rooms found in an examination of plans in five plan books of large companies doing a national business in ready-cut houses.

The plans used were of 183 five-room houses. In the analysis that was made it was found that, if dimensions of rooms only were considered it would not give a true picture, inasmuch as the sizes of rooms in these plans varied by inches, which meant a large number of different sizes of rooms. In order to reduce the number of different sizes they were grouped to the nearest one-quarter foot.

Room sizes were analyzed on the basis of area in square feet, using an interval of 10 square feet between the different areas. This interval was found desirable because it kept the graphs from spreading over too much territory. By analyzing on this basis, the most popular areas stood out very prominently, and then the popular sizes in these popular areas were picked out. Fig. 1 shows graphs for the four different rooms analyzed in this study.

Kitchens. The three most prevalent areas and the three most popular dimensions under each one are

1. Area, 80 to 89.9 square feet—8x10, 8½x10, and 8¼x11 feet.
2. Area, 90 to 99.9 square feet—8x12, 8½x11¼, and 9x11 feet.
3. Area, 100 to 109.9 square feet—8¾x11¾, 10x10, and 10x10½ feet.

Dining Rooms. In the 183 plans there were 149 dining rooms. The three most popular dimensions under each are

1. Area, 120 to 129.9 square feet—10x12, 10x12¼, and 10x12½ feet.
2. Area, 130 to 139.9 square feet—11x12, 11x12¼, and 11x12½ feet.
3. Area, 150 to 159.9 square feet—11x14¼, 11x14½, and 10½x14½ feet.

Living Rooms. There were 194 living rooms in the 183 plans. The three most popular dimensions under each, in the order of their choice, are

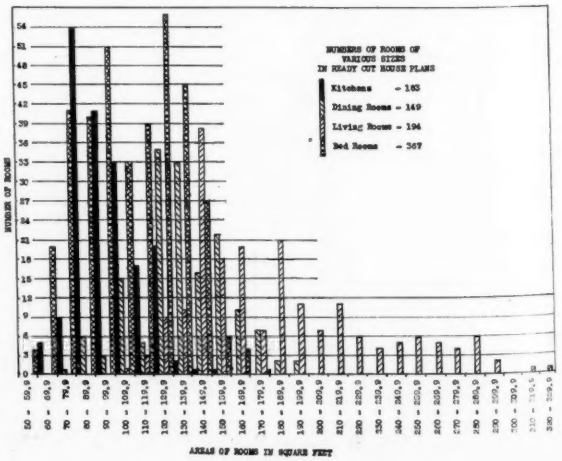
1. Area, 140 to 149.9 square feet — 10x14, 12x12, 11¼x12½ feet.
2. Area, 180 to 189.9 square feet—12¼x15½, 11¼x16, and 13¼x14 feet.
3. Area, 160 to 169.9 square feet—10x16, 12x14, and 12½x13 feet.

Bedrooms. There were 367 bedrooms in the 183 plans. For the three most prevalent areas, the three most popular dimensions in the order of their choice, are

1. Area, 120 to 129.9 square feet—10x12, 10½x11½, and 10½x12 feet.
2. Area, 90 to 99.9 square feet—9x10, 9½x10½, and 9¼x10 feet.
3. Area, 130 to 139.9 square feet—11x12, 11½x12, and 11¼x12 feet.

The most interesting thing about this analysis is that the size of rooms in the ready-cut houses are smaller, very much smaller, than will be found in the farm house plans and also in the plans for the houses designed by architects. The reason for this is apparent, in that the manufacturers of ready-cut houses are interested in giving to the buyer what looks like the most for his money. The average family attacks the problem of buying a house with two very definite facts: (1) The number of rooms they want in a house, and (2) the amount of money they have to pay for the house. Their yardstick for the size of the house is the number of rooms, and the ready-cut people cater to this idea and cut the cost by reducing the size of the rooms.

In the next article of this series, I will give results of an anaysis of a number of architects' house plans.


NUMBERS OF ROOMS OF VARIOUS SIZES IN READY CUT HOUSE PLANS
Kitchens = 183
Dining Rooms = 149
Living Rooms = 194
Bed Rooms = 367
NUMBER OF ROOMS
AREAS OF ROOMS IN SQUARE FEET

[1]Third of a series of articles presenting the results of an engineering investigation of farm house sizes and design.

[2]Professor of agricultural engineering, A. & M. College of Texas.

Experiments in Weed Eradication by Machine Applied Chemicals

By Kenneth R. Frost[1]
Jun. A.S.A.E.

THE INCREASING use of chemical liquid carbon bisulfide for killing perennial weeds necessitates the development of cheap and effective means of application. The cost of hand applications together with the cost of chemicals makes it infeasible to reclaim weeded areas unless large net returns per acre will warrant the high cost of weed eradication. The present methods of applying carbon bisulfide are very crude and unsatisfactory; moreover, these often result in injuries to the workmen due to the inflammability of vapor given off by the liquid. The vapor is readily ignited by sparks produced by the tools striking rocks in the soil.

To satisfy these conditions an experimental machine was developed to inject carbon bisulfide beneath the soil surface. The equipment chosen for the basic machine because of its variable depth control, was a one-prong subsoiler. The requirements of the machine were (1) to deliver a constant flow of chemical, (2) to eliminate hazards to the operator, (3) to provide control for one operator from the tractor, (4) to secure a means of covering the liquid so escape of the vapors could not take place, and (5) to deliver the liquid at varying depths below the surface.

A positive acting reciprocating pump constructed of cast and wrought iron was designed to meter and deliver the carbon bisulfide. This pump is power driven from the main wheels of the subsoiler so that the flow is controlled by the forward speed. The flow of liquid may be interrupted by the tractor operator by engaging and disengaging a clutch on an auxiliary shaft allowing the pump to start and stop. Fig. 1 shows a drawing of the pump, tank and driving mechanism.

The pump cylinder is suspended from the steel plate, A, of the supply tank into the liquid so the suction head is always negative regardless of the quantity in the tank. The cylinder is made of a 2-inch wrought iron pipe, giving a finished bore of 2⅛ inches. The suction and discharge are operated by ball valves equipped with coil springs to insure positive seating after each stroke. In order to make the discharge non-pulsating, an air chamber, B, is placed in the discharge line. The cast iron piston is operated by a scotch-yoke, and crank disk, D, thus providing a means of adjusting the discharge; by moving the crankpin in a slot on the disk which changes the length of stroke and gives the discharge desired.

The pump is designed to give a variation of flow from one to three ounces per foot of travel using a fixed ratio between the drivewheels and the pump shaft. This variation in discharge requires a change of one to 3.5 inches in the length of stroke. The pump volumetric efficiency was assumed to be 90 per cent for design purposes, but calibration results show an actual efficiency of 95 per cent. The high efficiency is due to the large valves, the negative suction lift, low discharge lift and the relatively slow piston speed. A forward speed of 2.5 miles per hour provides a speed of 96.5 rpm of the pump shaft. Fig. 2 illustrates the position of the pump and tank with respect to the subsoiler.

The piston was constructed of cast iron due to the necessity of using rings for a seal as carbon bisulfide dissolves rubber, leather, and fabric. Impurities in the carbon bisulfide are somewhat corrosive to iron, but if the mechanism is thoroughly washed with distillate after each operation no serious corrosion will result. The liquid is confined at all times, except at the discharge line, and the vapor pressure is too high throughout the system to allow an explosive mixture to form, so the fire hazard is reduced to a minimum. A rocky soil condition causes occasional sparks at the lower part of the shoe, sometimes causing ignition and slow burning of the liquid at the discharge end of the line. As the supply of oxygen is very restricted under the soil surface, the fire cannot pass up the discharge line. In case of danger the fire can easily be extinguished by closing the discharge and moving the machine forward.

Tests were made with experimental machines to determine the effect of varying the depth, amount of chemical, and the distance between applications. Plots densely cov-

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Table I. Conditions and Results of Weed Eradication by Machine Applied Chemicals

Date of application	Date of results	Soil condition	Ounces per lineal foot	Spacing, inches	Depth, inches	Rate, gal per acre	Results, % kill	Remarks
May 15	July 21	Dry mulch	2.00	20	8	310	90	Rained 1 week after application
May 15	July 21	Dry mulch	1.33	20	6	207	98	Rained 1 week after application
May 15	July 21	Dry mulch	1.33	20	8	207	96	Rained 1 week after application
May 15	July 21	Dry mulch	1.17	20	8	181	93	Rained 1 week after application
May 16	June 30	Unmulched	1.33	20	8	207	97	Rained 1 week after application
May 16	June 30	Unmulched	2.00	20	8	310	100	Rained 1 week after application
May 16	June 30	Unmulched	2.00	20	6	310	94	Rained 1 week after application
May 16	June 30	Unmulched	1.33	20	6	207	50	Rained 1 week after application
June 2	July 21	Dry mulch	1.00	30	12	101	78	Irrigated
June 2	July 21	Dry mulch	0.80	30	12	82	88	Remained dry and loose
June 2	July 21	Dry mulch	2.00	30	12	201	97	Remained dry and loose
June 2	July 21	Unmulched	1.33	30	8	135	88	Remained dry and loose
June 2	July 21	Unmulched	0.80	30	8	82	84	Remained dry and loose
June 2	July 21	Unmulched	2.00	30	8	201	89.5	Remained dry and loose
June 2	July 21	Unmulched	2.00	30	14	201	89	Remained dry and loose
June 2	July 21	Unmulched	1.33	30	14	135	89	Remained dry and loose
June 2	July 21	Unmulched	0.80	30	14	82	88	Remained dry and loose
June 2	July 21	Unmulched	0.80	20	14	124	88.5	Remained dry and loose
June 2	July 21	Unmulched	0.80	20	8	124	86	Remained dry and loose
June 2	July 21	Unmulched	2.00	30	8	201	87	Remained dry and loose
Sept. 5	Nov. 1	Unmulched	1.30	18	8	140	55.0	Remained dry and loose
Sept. 5	Nov. 1	Irrigated	2.00	18	8	310	60.0	Remained dry and loose

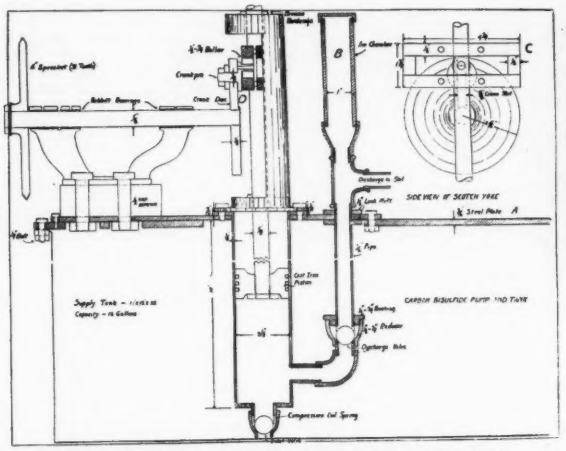

Fig. 1. Sectional view of reciprocating pump, tank, scotch-yoke, pump shaft, and driving sprocket

Fig. 2. Variable depth control subsoiler equipped with power-driven metering device, supply tank, and press wheel for delivering carbon bisulfide beneath the soil surface. Note the discharge line at the rear of the subsoiler prong

ered with orchard morning glories (bindweed, Convolulus arvensis) were used to test the applications. Several different soil conditions were obtained at various times during the growing season to determine the effect of soil factors. The conditions and results are given in Table I. The machine worked quite satisfactorily and at no time during the application was any mechanical trouble experienced.

The results show a maximum possible kill can be obtained by using 1.5 ounces of liquid per foot of travel, 20 inches between applications and 8 to 12 inches deep in a mulched soil. The time to apply carbon bisulfide is important to get the best results as indicated by the last two lines of Table I. Application made during the early part of the growing season seems to be the most effective.

No appreciable increase in kill is obtained with heavier application than given above. It is possible that depths less than 8 inches will allow the vapors to escape and greater than 12 inches may add expense to the operation without assurance of greater effectiveness. A firm, moist soil that packs well provides optimum conditions for application.

Water Equivalent of Snow

Editor AGRICULTURAL ENGINEERING:

AGRICULTURAL ENGINEERING for February 1932 contains an excellent article by Mr. G. D. Clyde in relation to water shortages on irrigation projects. There is, however, a misstatement of fact appearing at page 39 which should be corrected. The article as printed implies that the first measurements of the water equivalent of accumulated snow by the weighing method were made by Dr. Church in 1909. That is not the fact. Measurements by melting a prism of snow to determine the water equivalent of accumulated snow on the ground were taken throughout the winters of the years 1896-1900 at the Observatory of the Meteorological Institute of Prussia. The first measurements of this kind in the United States, of which the writer is aware, were those taken beginning in the winter of 1900 by Charles A. Mixer, of Rumford Falls, Maine, described in "Monthly Weather Review" of April 1903, pages 173-175. Mixer obtained the water equivalent of accumulated snow by melting a cut sample.

Apparently the first measurements of accumulated snow with apparatus of the modern type, where the water equivalent is obtained by weighing a sample, were those made by the writer at Utica, New York, in the winter of 1903-04. The results of these measurements, together with Mixer's data, the Potsdam results, and other early American measurements of water equivalent by the melting method, were published in the "Monthly Weather Review" for May 1905.

The apparatus developed by the writer at Utica, New York, and first used during the winter of 1903-04, embodied all the essential principles of the best modern apparatus, including a sampling tube with a cutting edge, smaller than the inside diameter of the tube, a vent for the escape of air and portable scales for weighing the samples. Dr. H. C. Frankenfield of the U. S. Weather Bureau visited Utica for the purpose of learning about this work and duplicates of the apparatus were made for the Weather Bureau and served as a prototype of most later apparatus.

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Editor AGRICULTURAL ENGINEERING:

REFERRING to Mr. Horton's statement in the foregoing letter, it was not my intention to imply that Dr. Church was the first to weigh a known volume of snow to determine its water content.

It was recognized in my paper (third paragraph on page 39) that studies of snow cover had been made for 100 years prior to the beginning of the 20th century when Mr. Charles A. Mixer made his first measurements. The method of cutting out a snow core and melting it to determine its water content was indicated.

The principle of weighing a known volume of a substance to determine its density was not new when Mr. Horton began his measurements of snow cover in 1903. In the May issue of the "Monthly Weather Review" for 1905 (page 196), Mr. Horton discusses the work of Mixer and the Potsdam experiments and his own work. The only reference he makes to his method is: ". . . . . and at successive points a tin tube about 3 inches in diameter was thrust vertically downward and a cylinder of snow obtained, whose equivalent water depth was accurately determined by weight." From a study of the measurements reported, it was concluded that this equipment was applicable for use only in a shallow snow cover. The idea, no doubt, of adapting the principle of weighing a known volume of a substance to determine its density, to the determination of the water content of a snow cover, originated with Mr. Horton and he should be given the credit for it. However, it was not until 1909 when Dr. Church of Nevada began his work that equipment was developed that was practical for use in deep snow on high watersheds.

I stand corrected to the extent that, as near as I can determine from available literature, the idea of weighing a core of snow to determine its water content originated with Mr. Horton, but I still maintain that it was not until Dr. Church's work in 1909 that satisfactory equipment for field determinations of water content of snow cover were developed.

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Associate Engineer, Utah Agricultural Experiment Station

A Reply to Mr. O'Neal's Suggestions

Editor AGRICULTURAL ENGINEERING:

THE remarks of Mr. Edward A. O'Neal, president of the American Farm Bureau Federation, regarding the testing of farm machines by the agricultural colleges, quoted in the first editorial of the February 1932 AGRICULTURAL ENGINEERING (page 54), opens up a subject which deserves the serious thought of every member of the American Society of Agricultural Engineers, especially those connected with the agricultural colleges.

Doubtless Mr. O'Neal made the suggestion in good faith, but if he or any other fair-minded person will give the matter full and careful consideration, he cannot help but reach the conclusion that such tests would be unnecessary, undesirable, and impracticable. There is no more reason why farm machines should be tested by state or federal institutions than there is why automobiles, sewing machines, shoes, or false teeth should be so tested.

The intimation that farm machines are placed on the market without adequate testing is unwarranted. Business reasons alone would be sufficient to prevent any reputable manufacturer from doing such a thing, because it would quickly ruin his reputation and trade. Even if there were manufacturers having no reputation to maintain and unscrupulous enough to sell useless machines, there are plenty of laws under which purchasers could obtain redress and such manufacturers and their agents could be punished.

The intimation that farmers as a class are so gullible that they can be induced to buy machines which will not do the work for which they are intended, is also unwarranted, in my opinion, and it overlooks the fact that in practically every case where there is any doubt whatever in the farmer's mind as to the usefulness of the machine on his own farm, he can and does have it demonstrated there, or orders it subject to approval.

Every new farm machine is tested by the manufacturer before offering it for sale. It is not placed on the market until it appears to be reasonably near perfection. Additional testing, whether done by the manufacturer or some other organization, costs real money. If done by the manufacturer, it will have to be paid for by the farmer in an increased price. If done by governmental agencies, it will have to be paid for in increased taxes. Advocates of additional testing overlook this very pertinent fact.

Admittedly, farm machines are not perfect when placed on the market, but neither is any other machine or invention. But who is to say when a machine is sufficiently developed to justify its being marketed? Most machines go through a period of development lasting over many years. For example, McCormick's reaper was about fifty years developing into the twine binder. Should it have been kept from the market until the seat for the raker was added? Or should it have been held up until the self-rake was perfected? Is it likely that the self-rake would ever have been developed if the hand-rake models had not been used in considerable quantities? It hardly seems possible that the twine binder would have been developed if the reaper had not been sold first.

Yet the crude old reaper is credited by high authorities with having won the Civil War, and with adding untold wealth to our nation by helping develop our agriculture and permitting large exports of grain.

The idea that a group of state or federal scientists would be competent to examine or test a new machine and decide accurately and finally whether it was practicable and valuable for use by farmers or others is an obvious fallacy. The best scientists of the day declared Edison's experiments to produce an incandescent light by heating a filament in a vacuum within a glass bulb were an utter waste of time. The committee on awards at the Centennial Exposition of 1876 passed over Bell's telephone as worthless, and finally gave it grudging recognition only because of the insistance of one of the inventor's friends. The introduction of the combine in the Great Plains and Middle West was greatly delayed by the freely and strongly expressed opinions of state and federal cerealists that its use in those sections was entirely impracticable. Yet this delay cost American grain growers far more than the purchase of imperfect machines has ever cost American farmers.

It is doubtless true, as Mr. O'Neal states, that many farmers have spent money for machines which proved useless to them. It is equally true that many farmers have spent money for pure-bred stock or certified seed which proved very unprofitable to them. But we all know that many other farmers have found pure-bred stock and certified seed highly profitable. And we all know that some farmers have found machines profitable to them which other farmers have declared useless. I believe it is an absolute fact, with which any fair-minded person familiar with the situation will agree, that for every dollar ever wasted by American farmers by buying machines which proved unadapted to their conditions, mechanically deficient, or unprofitable for any other reason, there have been many dollars wasted by going without machines which would have cut production costs and increased net profits.

The idea of having some governmental agency test farm machines and other commodities and pass upon their relative merits is by no means new. It has been suggested repeatedly, but always rejected as impracticable after full consideration, as it will be on this occasion, and on future occasions. The quickest way for anyone who has doubts on this point to convince himself, is to sit down and sketch a proposed organization for carrying on such tests on just one machine—any one he may choose—and go into some detail of the procedure which would be followed and the estimated expense of such work. At the same time, he should set down the benefits to be derived from this testing work, how the results are to be brought to the attention of the consumer, and the effect of such announcements on the business of the concerns whose products were tested.

He will quickly realize that, if consumers avail themselves of the facts disclosed by such tests (assuming that the tests can actually be carried out with sufficient rapidity and accuracy and at a not too prohibitive expense), only the machine which stands highest in the test should be salable. This is assuming that all machines in that particular class were intended to be of equal quality and price, for the uselessness of testing, comparatively, machines of admittedly different qualities and selling at prices commensurate with their quality, is obvious.

Unless consumers are all promptly informed regarding the results of such a test, and unless they act accordingly, certainly the expense of the tests cannot possibly be justified. If they all bought the machine which showed up best in the test, it is evident that the output of the manufacturer producing this machine would have to be tremendously increased. But what assurance could be given that the previous quality could and would be maintained in the increased production through the use of new workmen? A close governmental supervision and inspection of the entire output would plainly be necessary, requiring still more expense.

And what about the manufacturers, and their employes, whose products failed to obtain the highest rating? If consumers bought only the best, such other concerns would be forced out of business. Or would they be permitted to reduce their prices somewhat, if that were possible? If so, and if consumers still bought their products, surely the testing would have accomplished nothing worth while.

And why should not the manufacturer whose product proved best raise his price? He would surely be justified in this, on the basis of quality. Then the consumers would not only have to pay more than formerly, but would have

to pay the cost of the testing in increased taxes as well.

And who could say that the second-best machine, or one farther down the line, could not have a few minor changes made in it which would allow it to place first if given another chance?

Also, how many of each make of machine should be tested to avoid having a particularly good machine of a usually inferior quality show up best, or having an unusually poor machine from a line of usually high quality placed far down the list? If such tests did not establish relative merits beyond all doubt, they would be worse than useless.

In how many kinds of soil should drills, planters and tillage machines be tested? With how many kinds of seeds or crops? Under how many different conditions of soil moisture? At how many different depths? etc., etc.

Perhaps the most important factor of all would be the relative durability of machines. Yet the machine which was most satisfactory in other respects might not be very durable. What should be done about that? And how long should the durability tests last? Some machines could not be worn out in two or three years of continuous operation, and before the tests could be completed the manufacturer might have decided to change or discontinue that model, and other manufacturers might have developed still better machines. Tests which ignored durability would be of little value, yet in order to cover this point the results would be so much delayed that they would still be of little real value because of the changes constantly taking place.

The foregoing are just a few of the many obstacles which make official testing of machines or other commodities seem to those who have given the matter any real study altogether impracticable and prohibitive in expense. No amount of testing by the manufacturer's engineers or by government experts can be substituted for an actual trial of a machine in the hands of the final user, on his own farm, and under his particular conditions. An excessive amount of preliminary testing is expensive and unwarranted, no matter where done. It is just as unfair to the farmer to burden him with the cost of unnecessary testing as to sell him a machine not fully perfected and which might require some improvements made to it after purchase.

The illustration cited by Mr. O'Neal as indicating the need of official testing—the introduction of the tractor—is not at all pertinent. Not only was this twenty years ago, when conditions were quite different, but much of the blame for the set-back to the tractor business and to farming in the northwest, where the early tractors were introduced, rests upon other causes than the shortcomings of the tractors, crude as they seem when judged by the standards of today.

In the January issue of "Agricultural History," Harold E. Briggs describes the reasons for the rise and fall of "bonanza farming" in the Northwest without even mentioning the tractor. The facts are that far more of the large farmers in that section, in the early part of the present century, used only horses than used tractors, yet they all crashed together, though it has been a popular fallacy that tractors caused it, and only tractor users failed. This story was started by opponents of tractors, but was given wide circulation by people who could easily have learned the facts, but did not take the trouble to do so, as is so often the case.

Most of the early tractors were sold in newly settled regions where men were gambling with an unsafe system of farming and where service for machines of any kind was far from ideal. If the tractor users of that day had been sold the highly developed tractors of today, with service and other conditions as they were then, the outcome would have been no different.

Incidentally, many farmers will contend, and I believe rightly, that the quality of the service behind a machine is just as important as the quality of the machine itself. The best machine without adequate service may prove more expensive than a poorer machine with good service.

That the tractors themselves were not altogether to blame for failures of farmers in the Northwest is proved not only by the fact that many horse farmers also failed, but by the fact that the tractors used by some farmers who failed were bought by neighbors who used them with complete success. There were also numerous instances where the first purchasers declared their tractors failures and neighbors bought the machines and used them quite successfully. Not a few of these early tractors were kept in use for ten years or more.

Also, the history of the early tractors sold by established manufacturers of farm machines is quite different from that of numerous machines invented and produced by farmers, blacksmiths, mechanics and small concerns which had formerly been engaged in lines entirely foreign to farm equipment. There were at one time several hundred different makes of tractors on the market, but most of them sold in extremely limited quantities—in many cases not more than two or three were sold—a fact which tends to prove that farmers do not readily buy untried machines. At the same time, to hold the established implement industry responsible for the results brought about by these temporary manufacturers of tractors is unfair.

ARNOLD P. YERKES

The Engineer and Human Relations[1]

SUPPOSE the employee relations in a company were in a poorly organized and ineffective condition and the president of the company had called in the vice-president in charge to discover the reason. And suppose further that the vice-president had answered in this way: "My divisions are in such a bad position because the engineering department has worked so efficiently and conscientiously that it has developed the physical properties of the company to a very high degree of perfection and efficiency." Obviously, the president would be far from satisfied with the answer, and rightly so, for it would indeed be hard to even imagine conditions which would make the answer adequate.

Ridiculous and impossible as this sounds when applied to a single business, yet we find men in high standing in the country stating that it seems that the real achievements of science and engineering have failed because the human side of the world's problems has been neglected.

The implication seems to be that because a few (a small fraction of one per cent) of the people have in the past century or two applied themselves to the development of enginering and enginering science, gross neglect has fallen upon the field of human relations. The engineer and the scientist must drop their work, which has brought to man in a few years invaluable gifts, to delve into saving humanity along lines, which have for centuries defied the best efforts of our greatest minds.

Two causes are often stressed by certain of the people who are trying to find a basic cause for present world conditions. One is that the advances brought about by science and engineering are the cause, and the other is that engineers and scientists have been so busy with materialistic things that they have overlooked the interrelation of men and nations.

The latter, to say the least, while put forth as a criticism, is a decided compliment to the engineer and scientist, since it implies that they have but to shift the direction of their efforts toward human relations and all will be well.

To attribute to the engineer and scientist the ability to cure all because in their own field they have made satisfactory progress is not basically sound, nor is it proper to blame the ills of the world today upon their work because of this progress.

[1]Editorial in the Utilities Research Commission Bulletin of December, 1931.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

The Artificial Drying of Wood, F. Moll (Kunstliche Holztrocknung. Berlin: Julius Springer, 1930, pp. VI + 101, figs. 35).—This publication deals with the theory and practice of the artificial drying of timber. It contains chapters on the structure of wood, the relation of the wood mass to moisture, water absorption and water loss, variations in quality of wood resulting from dehydration, natural drying, artificial drying, artificial drying with air, structural members, and artificial drying in industries and factories.

Gas Engine Experiments [trans. title], A. Schnurle (Zeitschrift des Vereines Deutscher Ingenieure (Berlin), 75 (1931), No. 4, pp. 101-105, figs. 24; abstract in Science Abstracts, Section B—Electrical Engineering, 34 (1931), No. 403, p. 350).—Experiments are reported, the main portion of which dealt with the use of suction gas and lighting gas in a single cylinder engine, to determine the effect of the mixture ratio on the output, gas consumption, and heat loss.

The conclusions are that the maximum output is obtained only with a definite mixture, while there is a wider possible range of mixture for smaller loads. The best gas consumption at high loads is obtained with the greatest possible excess air, while at small loads the gas consumption falls at first and then rises as the air excess is increased. It was found that simultaneous adjustment of the inlet and exhaust valves gives regular operation and good gas consumption.

Viscosity-Temperature Relationship of Lubricating Oils, R. G. Sloane and C. Winning (Industrial and Engineering Chemistry (Washington, D. C.), 23 (1931), No. 6, pp. 673, 674, fig. 1).—A proposed method of graphical representation of the viscosity-temperature relationships of lubricating oils is briefly presented and discussed. A comparison of the graphs involved with those of other methods does not show perfect agreement. On the whole, the divergence is said to be surprisingly slight considering the complexity of the relation represented by a comparatively simple equation.

Flood Flows, A. Hazen (New York: John Wiley & Sons; London: Chapman & Hall, 1930, pp. VIII + 199, figs. 56).—This book presents the results of a study of frequencies and magnitudes of flood flows, and it contains chapters on definitions of flood quantities; method of plotting annual floods; data available for study; the coefficient of flood; the coefficient of variation; the coefficient of skew; drawing a smooth curve; tables and plottings; effect of one large flood; the three coefficients and the flood ratio factors; duration curve as a method; the extreme flood method; seasonal distribution of flood flows, and local and other factors; effects of great storms; effects of storage, forests, and land drainage; obstructions, debris, and sediment; changes in climate; and methods of flood protection.

Flame-Throwers in Locust (Schistocerca Gregaria, Forsk.) Control, K. A. Rahman (Agriculture and Livestock in India (Lyallpur), 1 (1931), No. 4, pp. 382-395, fig. 1).—The results of experiments conducted at the Punjab Agricultural College are reported, and a description of the flame-throwing machines developed are presented. The flame-thrower used is essentially a pneumatic knapsack sprayer fitted with a flame projecting appliance. It was found, however, that flame throwers are unsatisfactory as the chief means of dealing with the locust problem, but serve a very useful purpose as a subsidiary method of control. It is especially difficult to destroy hoppers resting among thick, green hedges by means of flame throwers. Thick hopper bands resting on shrubs or bushes which either easily catch fire or allow the flame to penetrate into every part can be effectively controlled. The times most suitable for working the flame thrower were found to be from 6 to 9 a m and from 5:30 to 7:30 p m. Though limited in its application, the flame thrower was found also to be an excellent appliance for speedily destroying benumbed, copulating, egg-laying and newly emerged adults

Potato Storage in the Central Provinces, J. F. Dastur (Agriculture and Livestock in India (Lyallpur), 1 (1931), No. 4, pp. 374-381, pls. 2).—The results of experiments on the storage of potatoes under conditions in the Central Provinces of India are reported. It is shown that during the monsoon months potatoes can be preserved as seed better in a less humid place than in a moist one. During the summer months potatoes can be preserved underground at a very small cost and without any appreciable loss.

The Cold Storage of Apples, C. West (Journal of Ministry of Agriculture (London) [Gt. Brit.], 38 (1931), No. 6, pp. 585-593, pls. 2, figs. 3).—Studies conducted at the Low-Temperature Research Station, Cambridge, England, are reported, in which an effort was made at the application of refrigeration to the preservation of English fruit. In addition, a summary is given of investigations conducted elsewhere. Some data also are given on the gas storage of apples, in which it is shown that this type of storage is particularly valuable for varieties of apples susceptible to low temperature breakdown. A list of ten references to work bearing on the subject is included.

A Reverse Slope Draining System, A. G. D. Bagot (Tea Quarterly [Tea Research Institute, Ceylon], 3 (1930), No. 3, pp. 73-76, pl. 1).—This system of hillside drainage and erosion control is described and illustrated.

New Paints from Synthetic Resins, D. H. Killeffer (Science of America (New York), 145 (1931), No. 4, pp. 238, 239, figs. 3).—The results of a few experiments with paints made from synthetic resins are briefly reported. It is stated that ways have been found of so modifying synthetic resin that it is soluble in such materials as china-wood oil. The combination yields a varnish similar in all respects to ordinary varnishes, but possessing greater durability, hardness, elasticity, resistance to washing, and the like. It also can be made to dry hard for a second coat in a time comparable with that required by lacquers. The fact that the new synthetic phenolic resins will not allow ultra-violet light to pass also greatly prolongs the life of varnishes made with them when exposed to sunlight.

It is also highly resistant to the action of any destructive agencies dissolved in water.

Good Practice in Construction, P. G. Knobloch (New York: Pencil Points Press, 1931, pts. 1-2, combined and revised, pp. 10, pls. 114).—Parts 1 and 2 of this publication have been combined and revised, and consist of a series of plates showing modern practice in building construction.

Elements of Water Bacteriology with Special Reference to Sanitary Water Analysis, S. C. Prescott and C. E. A. Winslow (New York: John Wiley & Sons; London: Chapman & Hall, 1931, 5. ed., rev., pp. IX + 219, figs. 2).—This is the fifth revised edition of this book.

Strength Tests of Creosoted Douglas Fir Beams, J. F. Harkom and G. H. Rochester (Canada Department of Interior, Forest Service (Ottawa) Circular 28 (1930), pp. 14, figs. 14).—This is a report of the effect of creosoting by the boiling-under-vacuum process on the strength of Douglas fir beams 6 by 12 inches by 13 feet in dimension.

The results show a reduction in strength due to incising and to treating separately and jointly. The total reduction for both incising and treating is 13 per cent, whereas the reduction for incising is 7 per cent and the reduction for treating alone is 13 per cent. This is attributed to the fact that incising prior to treatment decreases to a certain extent the checking which occurs in creosoting without previously incising by relieving seasoning stresses.

Guide for the Construction and Operation of Steam Silos for the Ensiling of Potatoes, E. Berendt (Leitfaden fur den Bau und Einrichtung von Heissdampf-Gruben-Silos fur Einsauerung von Futterkartoffeln. Hannover: M. & H. Schaper, 1931, pp. [3]-66, figs. 18).—This pamphlet describes a new method of potato steaming and ensiling and presents and illustrates the details of the process.

Stress Distribution in Reinforced Concrete Columns (Concrete and Construction Engineering (Detroit), 26 (1931), No. 9, pp. 528,530, fig. 1).—The results of tests of stress distribution in reinforced concrete columns conducted by the National Physical Laboratory in England are briefly summarized, from which a new method of determining stress distribution was deduced.

Heating Stock Water During Zero Weather, J. B. McLain (Electrical West (San Francisco), 67 (1931), No. 3, p. 135, figs. 2).—A brief description is given of equipment for the heating of stock water by electricity in areas of Idaho.

[Agricultural Engineering Investigations at the Arkansas Station] (Arkansas (Fayetteville) Station Bulletin 268 (1931), pp. 12-15).—Cotton machinery studies, by D. G. Carter, involving the use of the tractor as a power unit in cotton production, showed that all operations except hoe work and picking can be performed with approximately 8 man-hours per acre. The cultivation time requirement was found to vary directly with the capacity of the power unit. Chopping and hoeing were apparently not affected by the type of equipment used, and the labor required amounted to 32.35 man-hours per acre for the crop.

Field studies by Carter, conducted cooperatively with the U.S.D.A. Bureau of Agricultural Economics, on the utilization and cost of farm power, led to the general conclusion that a considerable increase in effectiveness could be gained in cotton production by the greater use of two-horse teams and the use

of tractors for more operations with machines of larger capacity.

Post preservation studies, by Carter and J. B. Woods, showed that creosote and water-soluble salts are reliable preservatives. Oil, sulfur, and spray solutions were not so effective, although there was some gain in durability. Service tests of vineyard fence posts showed that after eight years commercially creosoted round pine posts were sound, galvanized steel posts were in good condition, and painted steel posts were sound but rusted.

An underground water survey in the Grand Prairie area reported by Carter showed that there has been a gradual lowering of the ground water level from which water has been drawn for rice irrigation, which, in some areas, has amounted to from 20 to 35 feet. It is generally concluded that the safe yield of the water-bearing beds has been and is now being exceeded.

Preliminary studies of the water cooling of milk and cream by Carter and Woods indicated that milk at from 85 to 90° degrees (Fahrenheit) can be reduced to 65 degrees in 3 hours by the use of well water in milk-cooling tanks. The temperature of well water in northwestern Arkansas was found to average 59 degrees. It also was found that milk can be kept in a condition suitable for all sweet milk purposes for 12 hours and is acceptable for cheese factory use for 24 hours.

Rural Electrification in Virginia, C. E. Seitz and V. R. Hillman (Virginia Agricultural College (Blacksburg) Extension Bulletin 122 (1931), pp. 51, figs. 57).—The purpose of this bulletin is to explain the plan in operation in Virginia for extending electric high-line service to rural sections, and to indicate a few of the more important farm operations which are now being performed to advantage with electric power on Virginia farms. The report of a joint committee on rural electrification is appended.

A Colony Brooder House for the Farm Flock, J. R. Redditt and P. R. Hoff (Nebraska Agricultural College (Lincoln) Extension Circular 730 (1931), pp. 13 + [1], figs. 8).—Practical information is given on the planning and construction of a colony brooder house for Nebraska conditions.

A Note on Soils Regarding Their Suitability for Making Irrigation Engineering Works Exposed to Water, J. Charlton (Agr. and Livestock in India (Calcutta), 1 (1931), No. 2, pp. 119-127).—Studies are reported, the purpose of which was to develop a quick, simple, and reliable test of soils which will establish their suitability for making dams, liability to erosion, and the like. Special attention is devoted to the so-called kyatti, or sticky, soils.

The results, while very variable, indicate that the presence of carbonates lowers the tensile strength of clay-water pastes at the sticky point. It was also found that the majority of soils described as kyatti were strongly alkaline. Shaking these soils with either distilled or irrigation water in the ratio of 1 part of soil to 10 parts of water for a period of 1 hour caused these soils to be dispersed by the alkali which they contain and to give relatively stable suspensions. From the results it appears that a good soil will give a depth of settled material in the test tubes of less than 0.5 inch and no color or only very faint traces. Between 0.5 and 0.75-inch depth of sediment indicates soils which are potentially dangerous and the intensity of the pink color developed is a deciding factor. If the depth of sediment exceeds 0.75 inch, the soil is definitely a bad sample of kyatti and should be avoided if possible.

A general phenomenon noticed is that even where good surface soil free from kyatti occurs in the dry zone sampling to lower depths frequently indicates the presence of kyatti.

Terracing Experiments, 1930-31, H. H. Finnell (Stillwater, [Oklahoma] Panhandle Station Bulletin 31 (1931), pp. 3-9).—This is the third progress report of these experiments. In general, it has been shown that terraces must be built close enough together to prevent excessive accumulations of water at any one place in the field during heavy rains. Impounding more water in a particular area than the crop occupying that space can effectively utilize results in waste which markedly decreases the efficiency of the terrace system.

In run-off studies it was found that the percentage was largely affected by the character of cover or crop on the land, the least run-off being observed where grass was growing.

There appears a tendency for the moisture gains accruing from terrace-held water to be proportional to the amount of run-off liability experienced during the period of accumulation.

Judging from a study of the character of the rainfall for the 20-year period in which records are available and the 6-year period during which the terrace experiments have been conducted, it would seem a fairly safe conclusion to assume the 6-year period, 1926-1931, a good average representation of normal rainfall conditions.

The Adaptability of the Combine to Indiana Farms, I. D. Mayer and J. C. Bottum (Indiana Station (La Fayette) Bulletin 349 (1931), pp. 59, figs. 24).—This report presents the results of an investigation conducted partly in cooperation with the U. S. D. A. Bureaus of Public Roads, Plant Industry, and Agricultural Economics.

The data presented were obtained from (1) three years' records of farmer owned and operated combines, binders and small stationary threshing machines, and (2) field tests with six makes of combines controlled and operated by the station, three combines being used experimentally each year. Detailed records of the harvesting of each field on the owner's farm were obtained, together with records by crops of the combining done on other farms. Binder and thresher records were secured in the same vicinities in which the combines were operated. Performance tests to determine the efficiency of cutting and threshing grain were conducted on combines, binders, and small threshers which were being operated by farmers. On the three combines operated experimentally on Purdue farms, efficiency of operation, adjustments and attachments were studied and their performance compared with similar operations accomplished by the binder-thresher method of harvesting.

The results showed that grain from the combine was normally of as high a quality as that from the binder and thresher. When properly adjusted and operated the combine saved a higher percentage of grains harvested than did the binder and thresher. When weedy grain or a large acreage of weak-strawed grain, such as oats, was harvested the windrow method was more satisfactory than was direct combining. When more than 120 acres were cut annually, the average cost of harvesting with the combine was less than the average cost of harvesting with the binder and thresher.

The average total acre costs for combining were approximately two-thirds of the total acre costs with the binder and thresher. Approximately one-fourth as much labor was necessary to harvest with the combine as with the binder and thresher.

Appendixes discuss methods used in calculating combine costs and weather data. A list of sixteen references to recent literature on the subject is included.

Electric Hotbeds, R. R. Parks (Missouri Station (Columbia) Bulletin 304 (1931), pp. 16, figs. 10).—The material presented in this bulletin was read as a paper before the Royal Academy of Agriculture of Sweden on May 15, 1927.

The results of investigations on the use of electricity for heating hotbeds are given. It was found economical, ordinarily, to substitute electricity for manure in hotbeds when the cost of trucking and labor in handling the manure is considered. Operating costs on electric hotbeds were found to vary with the season, the crop grown, the insulation, and the method of handling. In general, from 100 to 250 kilowatt-hours are sufficient to heat a 6 by 12-foot hotbed for one season. Under Missouri conditions it was found that immersion heater cables will give essentially the same results as oven-type heaters and will cost considerably less. A 6 by 12-foot hotbed frame can be electrified for about $5.

Stresses in Wheels, E. G. Coker (Nature [London], 128 (1931), No. 3222, pp. 174, 175, figs. 2).—A brief summary of investigations of wheel stresses is presented, and curves showing the distribution of stresses are superimposed on wheel diagrams. These show that the combined effect of both axle and tire is to greatly increase the radial stress on the axle.

Biological Engineering, A. J. M. Smith ([Great Britain] Department of Science and Industrial Research (London), Food Investigational Board Report 1930, pp. 80-102, figs. 4).—A description is given of a refrigerating chamber in the Ditton Laboratory which is designed primarily for the study of problems of refrigeration control in the cold storage of fruit. A second refrigerating chamber is also described which can be used either as a ventilated storage without refrigeration or as a refrigerated storage without insulation.

In addition, experiments are reported on the refrigeration of different foods for the purpose of showing the importance of the different factors to be considered in research along this line. It is pointed out that water is the predominant constituent of foodstuffs commonly placed in cold storage. Special attention is given to data secured with eggs and apples, and to preliminary data secured with cheese. It was found with eggs that the rate of air movement at constant humidity has no effect upon the rate of evaporation, and that the rate of evaporation is limited by factors internal to the egg. It appears that the shell is the most obvious source of resistance to the passage of water vapor.

House Painting Methods with the Brush and Spray Gun, F. N. Vanderwalker (Chicago: Frederick J. Drake & Co., 1930, pp. 382 + [4], pl. 1, [figs. 142]).—This book deals with methods, materials, and tools essential to the painting of exterior surfaces of wood, metal, brick, and cement. It contains chapters on a survey of the market; brushes for painters and decorators, description, uses and care; mechanical spray painting equipment; ladders, scaffolds and swing stages; miscellaneous painters' tools; painter-mixed house paints; tinting colors and their uses; factory ready-mixed paints; paint oils, thinners, driers and removers; metal paints and painting; cement and brick paints and painting; a study of woods and surfaces; estimating material required; a job of painting with the brush; painting with the spray gun; exterior stains and staining; painting defects, causes, and remedies; the paint shop; and oxidizing copper surfaces.

Electric Wiring for the Farm, F. B. Wright and B. B. Robb (New York Agricultural College (Cornell, Ithaca) Extension Bulletin 204 (1931), pp. 122, figs. 121).—The purpose of this bulletin is to present some of the modern ideas and practices in electric wiring, particularly as they may be applied to farm uses.

Artificial Curing of Green Hay [trans. title], H. Edin, N. Berglund, and Y. Andersson (Kungl. Landtbruks Akademiens Handlingar och Tidskrift (Stockholm), 70 (1931), No. 6, pp. 845-947, figs. 11: Eng. abs., pp. 938-947).—In a contribution from the animal husbandry department of the Government Experiment Station of Sweden made in cooperation with the Swedish Association of Agricultural Engineering, investigations concerning the nutritional and technical problems on the preservation of green forage are reported.

In the artificial drying experiments, apparatus was used consisting of a heat generator with a spark collector, a fan for blowing the drying gases, a rotary kiln, a machine for cutting the fresh material, a forage grinder, and electrical apparatus. The heating unit was built of brick as a vertical furnace and was adapted for burning cheap firewood. The furnace gases were mixed with fresh air until the temperature desired was reached, and the mixture was blown by the fan into the drum. The kiln drum had a drying chamber in the center, around which were canals separated from the center by locked sheet iron. The gases were blown into the lower canals and from there into the locked sheet iron and through the green hay. The material was mixed by the rotation of the drum, but it was found that the uniformity as well as the speed of drying was dependent on the character of the material. Loose material dried more readily than more compact material. The capacity of the plant was from 550 to 620 kilograms (1,213 to 1,367 pounds) of fresh material per hour. At a temperature of the gases of 350 C the wood consumption was about 0.5 kilogram per kilogram of water evaporated and was from 1.5 to 3 kilograms of dried product.

Descriptions are also given of various other methods of drying hay artificially, including the open tray and endless conveyor methods. It was found that the most rapid and uniform drying is obtained by methods which allow all the grass particles to be suspended in the combustion gases while these are blown through pipes or canals. If the material is sufficiently ground and the temperature is high, grasses can be dried by these means in a few seconds.

Testing of Fire Resistance of Building Materials.—I, Brick Walls [trans. title], R. Schlyter (Statens Profningsanstalterna, Stockholm, Meddel, 50 (1931), pp. 62, figs. 35; Eng. abs., pp. 56-62).—The results of tests of the fire resistance of brick walls are reported, and the laboratory building, furnaces and test methods are described.

The fire laboratory is a building about 13 meters long, 8 meters wide, and 4.5 meters high; and consists of a furnace room and extinguishing room. It is connected with a heat-insulation and refrigeration laboratory of the same width, 11 meters long, and 3.5 meters high.

The vertical fire-testing furnace consists of a combustion chamber closed in front by the testing frame with the wall being tested and surrounded on both sides by five chambers filled with fireproof brick macadam. On the two walls at each end of the combustion chamber there are 21 gas burners. The horizontal fire-testing furnace has a horizontal combustion chamber 2 meters wide, 4.5 meters long, and 0.35 meter high. The bottom of this chamber consists of fire-clay bricks laid flat so as to cover horizontal channels running parallel to the short sides of the furnace. There are 9 gas burners on each of the long sides, thus making 18 burners with compressed air from the fresh air fan used in the fire laboratory for both the vertical and horizontal furnaces.

In the fire testing, a wall 3 meters high and 2 meters wide is inserted into the testing frame and subjected to a hydraulic load equal to that which it will carry in a building. It is placed in front of the furnace room, which is heated with gas to a high temperature. In this manner the wall is heated to the desired temperature, and then the heated side is sprayed with water. The horizontal furnace is used for testing beams or other horizontal structures.

The test results with brick walls showed that bricks which had not been sprayed with water did not show other damage than that the surface parts which were exposed to the fire were fused. There was no great spalling or cracking of the surface parts when the bricks were sprayed with water after being fire-tested for 4 hours or less. It is concluded that in tests not exceeding 4 hours the damage to brick is restricted to the surface parts. Tests of a sand-lime brick wall showed that the wall was in good condition after an 8-hour fire test and water application. A silurian brick wall gave the same results and tests as the sand-lime brick wall. The damage which occurred in a wall of hollow cement tile after a 1-hour fire test consisted chiefly of spalling on the exposed side alongside the cavities. The surface parts of a cinder-concrete wall which were destroyed after being subjected to a 4-hour fire test were washed away to an average depth of 3 centimeters. The material of the slabs was hard and solid at a greater depth.

During the actual fire test, loaded walls expanded vertically and deflected toward the fire. It also was found that moisture content greatly influenced the rise in temperature and the extent of the damage. Plastering apparently did not afford any protection to wall surfaces.

Absorption of Ultra-Violet Light by Lacquer Films, D. C. Duncan, D. R. Wiggam, and W. P. Davey (Industrial and Engineering Chemistry (Washington, D. C.), 23 (1931), No. 8, pp. 904-906, figs. 3).—Studies conducted at the Pennsylvania State College are reported which showed that within the ultra-violet range included in sunlight practically all the absorption of light energy by an ordinary lacquer is due to the ester gum. A considerable portion of this absorbed energy may reappear as fluorescent radiation, as electrons released photoelectrically from the gum, or as energy of collision of the second kind, in which the excited molecules in the gum transfer the absorbed energy directly to neighboring molecules in the nitrocellulose. The same effect is also present in the case of tricresyl phosphate and, to a smaller extent, in castor oil.

The nitrocellulose itself is sufficiently transparent to those radiations which have any considerable intensity in sunlight, so that it can be assumed that the failure of nitrocellulose in lacquer films is, for the most part, the result of secondary processes. This suggests that the light resistance of lacquers can be most easily improved by developing a nitrocellulose which is more resistant to electron bombardment, or by avoiding the use of fluorescent plasticizers and substituting some other gum suitable for lacquer purposes which is free from the objectionable absorption characteristics of ester gum.

Paint Thinners.—I, Effect of Different Thinners on the Durability of House Paints in Outdoor Exposure Tests, F. L. Browne (Industrial and Engineering Chemistry (Washington, D. C.), 23 (1931), No. 8, pp. 868-874, figs. 2).—The results of studies conducted at the U.S.D.A. Forest Products Laboratory are reported.

Exterior exposure tests at five stations made with two types of house paint on longleaf pine showed that variations in serviceability of coatings, caused by the nature of the volatile liquid with which the paint is thinned, are much less important than such factors as the pigment composition of the paint or the physical character of the wood painted.

Turpentine tends to make paint coatings more durable in proportion to the amount of residue it leaves permanently in the coating. When gum spirits turpentine was oxidized by heating and aerating and then used as a paint thinner, the durability was definitely improved. Steam distilled and destructively distilled wood turpentines meeting current specifications were found to be as acceptable as gum-spirits turpentine for thinning house paint. It also was found that the type of crude oil from which mineral spirits is refined does not affect the durability of paint coatings. Varnish makers' and painters' naptha, which evaporates more rapidly than mineral spirits, seems to make paint coatings more durable. It is suggested that the greater speed of evaporation leaves less time for the pigments to settle in the fresh coating and therefore results in more uniform dispersion of the pigments in the hardened coating. Solvent naphtha from coal tar was found to have no advantages over turpentine or petroleum distillates as a paint thinner.

Electric Motors for the Farm, F. J. Zink (Kansas Agricultural College (Manhattan) Extension Bulletin 69 (1931), pp. 23, figs. 15).—Practical information is given on the adaptation of electric motors to different farm operations, including tabular data on motor sizes, styles and types.

Important advantages of the electric motor are its adaptability to many machines and its large overload capacity. It has been found that a 0.25-horsepower motor will do as much work as a man at hard labor turning a crank. Two portable motor units, a 0.25 or 0.5 and 5 or 7.5-horsepower motor will care for all the usual farm machines not provided with attached motors. An individual motor drive should be used for those machines which are operated frequently or are operated for considerable periods of time.

The line shaft drive is not recommended for electric motors. Pliable belts without heavy lacing give greater satisfaction for drives. Fuses are not generally adequate for the protection of a farm motor against injury through overheating. Suitable overload protection should be used with all motors.

An appendix is included which describes types of motors.

Elastic Deformation of Wooden Rods Under Tensile Stress [trans. title], H. Sieglerschmidt and J. Stamer (Ztschr. Ver. Deut. Igen. (Berlin), 73 (1929), No. 46, pp. 1649, 1650, figs. 4; abs. in [Gr. Brit.] Dept. Sci. and Indus. Research, Bldg. Sci. Abs., n. ser., 3 (1930), No. 1, pp. 21, 22).—A brief account, accompanied by diagrams, is given of measurements of elongation and transverse contraction of wood. Six specimens (250 millimeters (10 inches) long, 30 millimeters (1-3/16-inch diameter), i.e., 3 of pine, 2 of oak, and 1 of birch (compressed) were subjected to tensile stress (up to 28 kilograms) per cubic centimeter (398 pounds per square inch), and measurements were made tangentially and perpendicularly to the annual rings and in intermediate positions.

It was found that (1) the elongation figures and moduli of elasticity were practically independent of direction of measurement. Hence, distribution of stress over the transverse section was uniform. (2) The transverse contraction figures and the ratio of transverse contraction to elongation (reciprocal of Poisson's ratio) decreased from position 0 (tangential) to 90 degrees (radial). In the birch specimen tensile stress caused expansion tangentially to the annual rings and contraction in a radial direction. It was found also that the values of the ratio of transverse contraction to elongation in no case exceeded 0.5 as the average for the directions between 0 and 90 degrees, i.e., they remained within the limits found for metals. This would apparently indicate that wood becomes denser under tensile stress.

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The Engineer's Responsibility

GENERAL CHARLES GATES DAWES would have us say that we are now entering upon a period of reconstruction. I have no reason to do other than agree with General Dawes. A critical situation is never improved by emphasizing the elements of fear and distrust, nor will mere optimism alone as such turn the trick.

The agricultural engineer has at this time a grave responsibility not only as a constructive thinker but also as one who has confidence in his profession and the future.

During the period of declining farm prices, buildings have been neglected. New buildings have not been constructed as needed and existing buildings have been allowed to depreciate.

Most advances in economic production are made during periods of unfavorable markets. Profits are determined by the spread between cost and selling price, and by the quantity produced. Well-planned buildings will contribute in increased production, better preservation, or more efficient operation.

Never has there been a time when it was more essential to secure, by careful planning, the maximum for the expenditure made. Many farmers cannot operate effectively and economically with their present farm plants. Their buildings are not in the best of condition and in many cases are ill-suited to their needs.

There is much work to be done in helping them to build, remodel, and repair in keeping with requirements, using available materials to their best advantage to assure long productive life.

If the agricultural engineer doesn't do it, who will?

HENRY GIESE[1]

Another University Falls in Line

AS REPORTED elsewhere in this issue, the University of Illinois has recently rechristened its department dealing with farm machinery, structures, land reclamation, rural electrification, etc. What it formerly called its department of farm mechanics is now known as its "department of agricultural engineering."

This is substantial recognition from high authority of the true nature and caliber of work done by the department. E. W. Lehmann, head of the department, and other members of the staff are to be congratulated.

Agricultural engineering involves much more than mechanics. It is separate and distinct from agricultural economics and from agronomy, with which it is grouped in a few cases. It is broader than its direct application as "farm engineering." It is not as broad as the term "rural engineering," for much that is rural is not agricultural. It is the name wisely selected twenty-five years ago by a group of engineers, for an engineering need and opportunity which they foresaw in outline and had begun to develop.

Recognition of their departments of agricultural engineering as such by practically all land-grant colleges means more than standardization upon one name. It is acknowledgment of a justified claim by the agricultural engineering profession to a large and well-defined field of service.

Some Farmer's Week Observations

FARMER'S WEEK is an annual event in many state colleges of agriculture—an event which attracts to the college for the benefits of contact and new agricultural information, a fair cross section of the more progressive farmers of the state. An incidental benefit of the programs is the inevitable revelation of the trend of thought of these farmers.

At a recent Farmer's Week in a corn belt state the total attendance dropped 40 per cent, presumably due to the deflated condition of the farmers' pocketbooks. But the lectures on agricultural engineering were attended about as well as, and in some cases better than during the same week a year ago. Interest in information on care and repair of equipment was particularly evident. Attendance at a five-day series lecture on care and repair of the tractor fell off only 11 per cent. This compares with the 40 per cent decrease in total attendance even more favorably than the figures alone suggest, because the percentage of decrease in the total number who stayed the full five days would no doubt be even greater than 40. Some farmers came in primarily for the five-day series lecture.

The head of the agricultural engineering department concerned checked up especially on widespread reports that farmers are going back to horse power. He found a sharp division of opinion among the farmers as to which type of power would be most economical to use this spring. Those who had both horse and tractor power had been using the horses for plowing when possible due to the open winter. This practice of using horse power for off-peak draft loads, where both sources of power are available, is easily understandable during a time of low feed prices and stringent cash and credit conditions. It is also easy to see how careless or partial observers might easily and erroneously conclude, from observing the number of horses and tractors in use under these circumstances, that there is a marked swing back to animal power. In fact, however, the practice reflects a temporary condition rather than a heavy and permanent balance of advantage on the side of horse power. Any who are skeptical as to the truth of this will do well to observe farmers closely during the approaching peak load seasons. Serviceable tractors may be expected to be put into use by their owners, to save time if for no other reason, and horse power shifted from carrying the major off-peak loads to carrying the portion of peak load in excess of tractor power capacity. Presumably few farmers who have tolerably satisfactory power, either animal, tractor, or both, will make any radical changes from one to the other this spring.

On the matter of specific production costs the department head found those farmers who were businesslike enough to know their costs, somewhat "cagey." They were disposed to let all who would cry for higher farm prices, and not to brag about how low their costs were, but to learn all possible from the men who had taught them earlier lessons in cost cutting. We see in this a subtle working of the law of self-preservation.

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A.S.A.E. and Related Activities

Meetings Committee Reveals Plans and Progress on 1932 Annual Meeting Program

PRECEDENT has been cast to the winds by the 1932 A.S.A.E. Meetings Committee in planning the annual meeting to be held at Ohio State University, Columbus, Ohio, June 20. Dr. E. A. White, chairman of the Committee, in a recent announcement of its general plans, mentioned specifically four different innovations calculated to improve on time honored annual meeting practices and to inject compelling interest into the program.

In outline the schedule will be as previously announced, the College Division holding forth on Monday, the opening day, with simultaneous sessions on extension and research, the mornings of the remaining three days being given to general sessions and the afternoons split into two distinct periods of technical division sessions. Each of three or four of the general sessions papers is being scheduled to give information and recognition to an outstanding technical development of general interest.

Believing that agricultural engineers should be guided by a fairly definite conception of "An Engineer's Policy for Agriculture" the Committee is arranging for three speakers and discussion from the floor on this theme.

To give the assembly a better idea of what family-sized farmers expect of them a high type of family-scale farmer is scheduled to tell "those engineers" face to face what he thinks they ought to do for him and others of his kind.

Raymond Olney, secretary of the Society, will review in his report the developments of the past year, leaving the well-disciplined and highly productive imagination of Leonard J. Fletcher to roam, in his presidential address, where it will.

The four technical divisions will so coordinate their programs that during the three afternoons available no more than two sessions will be in progress simultaneously. Some of these will be joint sessions of two or more Divisions for consideration of technical papers of common interest. The committee believes that this arrangement will give each Division sufficient time to consider, in a carefully built program with condensed papers and a minimum of wasted time, all technical matters which demand its consideration.

Details of the College Division session will be worked out by the Division's Advisory Committee during its annual meeting in Washington, D. C., March 9, 10 and 11. The Division's Committee on Student Branches has been detailed to plan a special session for Student members of the Society.

Conferences on teaching and extension sponsored by the College Division immediately preceding the past two or three annual meetings have proved so successful that the Division this year will precede its session by separate, simultaneous conferences on research and on extension. These will probably be two or three-day affairs. C. E. Seitz, chairman of the College Division, has delegated the responsibility for these conferences to special committees.

In a few words, the Meetings Committee is aiming toward mechanical and technical perfection in the program for this year's annual meeting; and is making substantial progress in its arrangements for achieving that perfection.

University of Illinois Changes Department Name

AGRICULTURAL engineering activities at the University of Illinois will henceforth be in charge of the department of agricultural engineering at that institution. The only change is in the name of the department, which was until recently the department of farm mechanics. Final approval of the change was given by President Chase of the University of Illinois upon recommendation of the deans of the College of Engineering and the College of Agriculture.

Changes in curriculum and administration also proposed by the department with a view to offering a degree in agricultural engineering have been held up for the time being for economic reasons. E. W. Lehmann, head of the department, reports that in spite of this fact several of his students are already working for their bachelor's degrees in agricultural engineering.

Southern Section Meets with Southern Agricultural Workers

AS HAS BEEN its custom for the past few years, the Southern Section of the American Society of Agricultural Engineers held its recent annual meeting in conjunction with the annual convention of the Association of Southern Agricultural Workers. Gathering at the Tutwiler Hotel in Birmingham, Alabama, for the three days, February 2, 3 and 4, the Association members spent their mornings in general sessions and their afternoons in sectional group meetings according to technical interest.

Leonard J. Fletcher, president of A.S.A.E., addressed the general session on the morning of February 2. This session was devoted to the theme of "Land Utilization in the Cotton Belt." President Fletcher spoke on the "General Relation of Power Farming to Effective Land Utilization."

The agricultural engineers heard President Fletcher again in an address more particularly to them, at the opening of their Section program Tuesday afternoon. During the same session, R. B. Gray, agricultural engineer, U.S.D.A., told them about "Cooperative Work Pertaining to Farm Machinery in the South"; W. A. Clegg, agricultural engineer, Caterpillar Tractor Co., gave a "Method of Analyzing the Farm for the Use of Machinery"; and Wm. E. Meek, Jr., agricultural engineer, International Harvester Co., presented "The Implement Dealer's Responsibility to His Community."

In a business meeting at the close of the session, Mr. Clegg was elected chairman of the Section for the ensuing year. Other officers elected were first vice-chairman, A. Carnes, assistant professor of agricultural engineering, Alabama Polytechnic Institute; second vice-chairman, J. O. Smith, agricultural engineer, Delta Experiment Station, Stoneville, Miss.; and secretary, J. W. Randolph, agricultural engineer, U. S. Department of Agriculture.

On the program the second afternoon were papers on "Development of Agricultural Engineering," by S. H. McCrory, chief, Bureau of Agricultural Engineering, U.S.D.A.; "Methods of Studying Soil Erosion," by M. L. Nichols, head of the agricultural engineering department at Alabama Polytechnic Institute; "Development in Electrical Operations on the Farm," by Dr. E. A. White, director of the National Committee on the Relation of Electricity to Agriculture; "Progress in Rural Electric Development," by H. M. Weathers, chairman of N.E.L.A.'s Rural Electric Service Committee; and "Engineering Adjustments on Southern

Farms" by S. P. Lyle, agricultural engineer, U.S.D.A.

A like number of papers filled the program for the third afternoon. W. H. Danner, adjunct professor of agricultural engineering, Georgia State College, reported on "Temperature Studies of Household Refrigerators." Cotton drying and ginning was covered by Chas. A. Bennett, engineer in charge, U. S. Cotton Ginning Laboratory, Stoneville, Miss. D. W. Teare, associate professor of agricultural engineering at Clemson College, presented a "Comparison of the Quality of Machine Snapped Cotton and Hand Picked Cotton." J. T. McAlister, extension agricultural engineer at Clemson College, told of an "Extension Project in Farm Machinery." Closing paper on the program was by Mr. Randolph, newly elected secretary of the section, on "Measuring Power Units in the Field and Laboratory."

A.S.A.E. members also contributed to the programs of other sections of the meeting. G. A. Cumings, agricultural engineer, U.S.D.A., was senior author of a paper on "Results of Cooperative Tests with Cotton in Seven States, 1931," which was part of an Agronomy Section symposium on fertilizer placement. D. A. Isler, also with the U.S.D.A. Bureau of Agricultural Engineering, was senior author of a report on "Three Years' Results in Controlling the Pink Bollworm in West Texas by Cultural Practices," presented before the meeting of the Cotton States Branch of the American Association of Economic Entomologists.

National Drainage, Conservation and Flood Control Congress

FOR ITS twenty-first annual session the National Drainage, Conservation and Flood Control Congress convened at Louisville, Ky., February 17, 18 and 19. Consideration was also given to drought control, and erosion control by reforestation. These major interests were dealt with in papers and addresses presenting engineering, legal, economic and social angles of important problems, studies and developments.

A.S.A.E. members who filled prominent places on the program were Charles H. Young, consulting engineer, Muscatine, Iowa; E. V. Willard, state water and drainage commissioner for Minnesota; and Lewis A. Jones, Chief of the division of drainage and soil erosion control, U.S.D.A. Bureau of Agricultural Engineering. They presented the first three of four papers on the program for the first afternoon in the following order: Mr. Jones, "Present Needs in Drainage Work"; Mr. Young, "The Effect of the Nine-Foot Channel on Drainage Systems and Municipalities"; and Mr. Willard, "Federal Relief for Refinancing of Drainage Indebtedness."

Mr. Young also responded, for the Congress, to the mayor of Louisville's address of welcome, and presided at the second afternoon session of the meeting. Mr. Willard presided during the morning session of the second day.

A.S.A.E. Members on International Congress Program

TWO A.S.A.E. members are listed among the contributors from the United States to an International Congress for Scientific Management, to be held at Amsterdam, Holland, July 18 to 23 of this year.

Wheeler McMillen, associate editor, "The Country Home," will represent A.S.A.E. unofficially and contribute a paper on the general subject of engineering advances in Dairy Production.

Eloise Davison, home economics adviser National Electric Light Association, is to contribute a paper as a representative of another organization. It will be on the general subject of determination of standards for the establishment of household budgets in money, time and energy.

One hundred papers on twelve subjects, by authors throughout the world, have been scheduled. The twelve subjects are (1) a. uniform cost accounting, b. standard costs; (2) budgets as a basis for the extension of bank credit; (3) market study: the basis for launching a new product by advertising; (4) the training of foremen in modern management methods; (5) the essentials of a rational system of promotions; (6) a. collegiate courses for management, b. how should the program of teaching the principles of rationalization be prepared? how should the instruction of industrial personnel be effective?; (7) relative advantages of different methods to be used to interest workers in increasing their efficiency; (8) determination of standards for the establishment of household budgets in money, time, and energy; (9) stock turnover in its relation to net profits; (10) engineering advances in dairy production; (11) how should scientific management be applied to industries with mass production of a single article—to industries with standardized mass production in a few lines—to industries without standardized mass production—to industries where every article is made to order; (12) the application of incentive wage payment plans to office work.

Several American economic and engineering organizations are cooperating with the International Management Congress Committee of the U. S. A. Advance registration forms and other information may be obtained from that committee at 29 West 39th Street, New York City.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the February issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Earl Lee Arnold, extension assistant in agricultural engineering, New York State College, 214 Thurston Ave., Ithaca, N. Y.

F. Leslie Foss, assistant manager, Greenfield Electric Light & Power Co., Greenfield, Mass.

John Lowe, assistant architect, Architects Office, Department of Agriculture, Central Experimental Farm, Ottawa, Canada.

Laurence M. Whiting, West Concord, Minn.

Transfer of Grade

P. C. McGrew, agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture, State College of Washington, Pullman, Wash. (Assoc. to Member)

New ASAE Members

Harvey S. Clapp, farmer, Accotink, Va.

Frank Cornell, president, Cornell Tractor Co., 10 Abbott St., Salinas, Calif.

Merle F. Feather, sales representative, Blood-Brothers Machine Co., Allegan, Mich.

Miner J. Markuson, assistant professor of agricultural engineering, Massachusetts State College, Amherst, Mass.

A. W. McCalmont, Western manager, Manufacturers Service Division, Vacuum Oil Company, Inc., 903 W. Grand Blvd., Detroit, Mich.

Mario Montemayor, timekeeper, Tela R.R. Co., Honduras, C.A.

Russel J. Phillips, district sales manager, Dairy Equipment Department, International Harvester Co., 105 Fulton Ave., Cincinnati, O.

Ralph Archibald Ross, rural engineer, Potomac Edison Co., Middletown, Md.

George R. Shier, junior agricultural engineer, U. S. Bureau of Agricultural Engineering, 1110 Electric Bldg., Richmond, Va.

Milburn L. Wilson, head, department of agricultural economics, Montana State College and Agricultural Experiment Station, Bozeman, Mont.

Transfer of Grade

Grant N. Denike, assistant superintendent, Dominion Experimental Station, Swift Current, Saskatchewan, Canada. (Junior to Associate)

Frank J. Zink, associate professor of agricultural engineering, Kansas State Agricultural College, Manhattan. (Associate to Member)